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Precambrian Geology of Street Township, Southern and Grenville Provinces

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Precambrian Geology of Street Township, Southern and Grenville Provinces

by

R.M. Easton and E.I. Murphy

2002

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GEOLOGICAL MAP

Preliminary Map P.3427 — Precambrian Geology of Street Township ..... back pocket

Abstract

Street Township is located roughly 25 km east-northeast of Sudbury, Ontario and covers an area of approximately 100 km^2.

The bedrock is Neoarchean to Mesoproterozoic in age and is part of the Southern and Grenville provinces. Street Township is divided nearly in half by the Grenville Front which marks the boundary between the Southern and Grenville provinces.

The northwest half of Street Township is underlain by metasedimentary rocks of the Hough Lake, Quirke Lake and Cobalt groups of the Paleoproterozic Huronian Supergroup. These rocks are intruded by gabbro sills of the 2200 Ma Nipissing intrusive suite. All these rocks have been affected by folding and faulting related to the Penokean Orogeny (1870 to 1830 Ma) and by brecciation and faulting related to the formation of the Sudbury Structure at 1850 Ma. Subsequent geological events affecting rocks of the Southern Province in Street Township include sodium metasomatism and associated gold and copper mineralization along regional faults at approximately 1700 Ma, and intrusion of Sudbury swarm diabase dikes at approximately 1238 Ma.

The southeast half of the map area is underlain by gneissic rocks of Neoarchean, Paleoproterozoic and Mesoproterozoic age that have been metamorphosed and deformed during the late stages of the Grenville Orogeny at roughly 1000 Ma. Rocks of Neoarchean age include amphibolites, of possible metavolcanic and intrusive origin, as well as metasedimentary gneisses. The Neoarchean rocks were subjected to a high-grade metamorphic event prior to the intrusion of a suite of Paleoproterozoic mafic to ultramafic rocks. The Paleoproterozoic mafic to ultramafic rocks can be correlated, on the basis of geochronology and geochemical signature, with rocks of the East Bull Lake intrusive suite (circa 2475 Ma). The Neoarchean rocks, as well as the East Bull Lake intrusive suite, are intruded by an unnamed suite of felsic intrusions that were emplaced at approximately 2460 Ma and are likely coeval with felsic volcanism associated with the lowermost Huronian Supergroup. Metavolcanic and metasedimentary rocks, correlative with the Elliot Lake and Hough Lake groups of the Huronian Supergroup, and amphibolites that have comparable geochemical signatures to the Nipissing intrusive suite, occur discontinously within a 2 to 3 km wide zone within the Grenville Province immediately southeast of the Grenville Front. Huronian Supergroup or Nipissing intrusive suite rocks have not been recognized in the interior of the Grenville Province.

Highly migmatitic rocks, more than 2 to 3 km inboard from the Grenville Front, occur within the Grenville Province in Street Township. The protolith for these rocks is uncertain due to the high degree of migmatization and deformation. The migmatitic rocks are all characterized by abundant almandine garnet porhyroblasts ranging from 5 to 25% of the rock. It is suspected that these migmatitic rocks are equivalent to the Neoarchean and Paleoproterozoic rocks observed closer to the Grenville Front, however, they have been affected by partial melting associated with Grenville metamorphism and deformation.

The boundary between the Southern and Grenville provinces (i.e., the Grenville Front) is marked by a single fault for most of its length in the map area. The Grenville Front is east-northeast striking and has been displaced, a minimum of 850 m to the north, along the north-striking Upper Wanapitei River fault, which extends through the centre of Street Township. The Grenville Front is coincident with the Wanapitei fault in the southwest corner of Street Township. In the northeast corner of Street Township, along Timmins Creek, the Grenville Front is coincident with the Ess Creek fault. In the Timmins Creek area, the previously mapped location of the "Grenville Front boundary fault" coincides with the boundary between migmatitic and non-migmatitic rocks within the Grenville Province.

Within the Southern Province, mineral potential is restricted to the presence of nickel-copper and possibly platinum group element mineralization in Nipissing gabbro intrusions and gold-copper mineralization associated with sodium metasomatized rocks along regional fault systems.

Within the Grenville Province, rocks of the East Bull Lake intrusive suite are known to be favourable targets for nickel-copper and platinum group element mineralization, especially along preserved intrusive contacts of the bodies. Rocks of this suite are more abundant east of Street Township, however, and this area is a more favourable for this type of mineralization.

Adjacent to the Grenville Front, metavolcanic rocks of the Huronian Supergroup provide interesting targets for base metal mineral exploration, especially in areas where sulphide mineralization was previously discovered in the early 1980s.

Some of the Neoarchean rocks within the Grenville Province contain abundant, large garnets or kyanite or both. These rocks have been the focus of active exploration over the last decade with respect to their industrial mineral potential. The most favourable area for finding garnet-rich rocks for industrial mineral applications is within a 2 to 3 km wide zone immediately adjacent to the Grenville Front. Migmatitic, garnet-bearing rocks, located further inboard of the Grenville Front, have lower garnet contents, and the garnets are varied in size and contain more deletrious gangue minerals.

Precambrian Geology of Street Township, Southern and Grenville Provinces

R.M. Easton[1] and E.I. Murphy[1]
Ontario Geological Survey
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Introduction

Street Township (part of NTS 41I/10SE) (Figure 1) is located roughly 25 km east-northeast of Sudbury, Ontario, and lies within the District of Sudbury. The map area covers about 100 km^2, and is bounded roughly by latitude 46°32′15″N and 46°37′15″N and longitude 80°38′30″W and 80°36′W. No communities are located within Street Township.

There is no record of mineral production within the map area, and mineral exploration has been minimal (Ontario Geological Survey 1987). Recent exploration activity has focussed on gold (Gates 1991; Williams 1992), garnet, and platinum group elements (PGEs) (Newman 1996; Easton 1999a).

ACCESS

Access is provided by the Kukagami Lake road, which joins Highway 17 (Trans-Canada Highway) roughly 10 km east of the community of Wahnapitae. Kukagami Lake road extends northerly through the central part of the township. Access is also provided by an abandoned Canadian National Railway right-of-way extending east through northern Street Township, as well as several old logging roads and various all-terrain vehicle and snowmobile trails. Water access to the western part of the township is provided by the Wanapitei River.

PHYSIOGRAPHY

Relief in Street Township is less than 100 m, ranging from roughly 255 m above sea level on the Wanapitei River to about 325 m above sea level in the west-central and north-central parts of the township. Throughout much of the township, outcrops are generally steep-sided, and rise 3 to 30 m above the surrounding topography. Both the western and eastern parts of the township drain into the Wanapitei River, which flows south from Wanapitei Lake toward Coniston.

Distribution of outcrop is varied. Exposure is poor (15 to 20%) in the western part of Street Township, especially those portions underlain by metasedimentary rocks of the Huronian Supergroup and along the trace of the Grenville Front. Exposures are abundant (50 to 70%) in areas of the Grenville Province that are underlain by mafic gneisses. In the eastern and central parts of the township, outcrop areas are only thinly covered and vegetated, likely reflecting past effects of fume kill from the Coniston and Falconbridge smelting operations, which lie upwind of the township (*see also* distribution of Cu, Pt, Pd in humus in Tardif 2000). In contrast, in areas distal to these operations, such as the northeastern part of the township and along the Street–Loughrin township boundary, both lichen and forest cover increases markedly.

PREVIOUS GEOLOGICAL INVESTIGATIONS

Although proximal to Sudbury and including rocks of the Southern Province, Street Township was not subjected to previous detailed geological investigation, even though adjacent townships to the west and north have had a long history of geological study. Collins (1913) briefly described the character of rocks located near the present Southern–Grenville province boundary in Street Township. Fairbairn (1939) mapped the area southeast of Wanapitei Lake, including Street Township at 1:31 680 scale, but did not

subdivide rocks within what is now known as the Grenville Province. He did, however, recognize the presence of metaconglomerate within the Grenville Province in the Timmins Creek area. Kindle (1933), as part of a regional mapping project in the Wanapitei Lake area, described 4 mineral occurrences located in Street Township. Thomson (1961), in his study of Maclennan and Scadding townships to the north, mapped some outcrops in northernmost Street Township. Street Township was included in Lumbers' (1973) 1:63 360 scale map of the Sudbury–River Valley area. Most significantly, Lumbers (1973) noted the presence of Huronian metavolcanic rocks in the Timmins Creek area. McLean (1983) produced a geologic strip map roughly 750 m wide along the Grenville Front from central Street Township to the northeastern corner of the township. Dressler (1984a) included the western half of Street Township in his 1:50 000 scale compilation map of the Sudbury area, and identified a major syncline cored by previously unidentified Gowganda Formation conglomerate in western Street Township. Debicki (1990) measured three stratigraphic sections in the Huronian Supergroup in central Street Township, immediately west of the Grenville Front, as part of her stratigraphic study of the Huronian Supergroup in the Sudbury area. Gates (1991), in a regional study of sodium metasomatism east of Sudbury, described 2 gold showings in Street Township that had been previously examined by Kindle (1933). Williams (1992) conducted a detailed study of a gold showing in the Timmins Creek area immediately south of the Grenville Front. Davidson (1998) described the geology of the Southern and Grenville provinces immediately adjacent to the southwest corner of Street Township. Grant et al. (1962) described kyanite-bearing gneiss and associated paragneiss in Dryden Township; equivalents of these rocks strike into Street Township. Street Township was included in the River Valley area studied by Tardif (2000) for platinum, palladium, gold and kimberlite indicator minerals in surficial materials.

PRESENT GEOLOGICAL SURVEY

Street Township was mapped for the following reasons.

1. The township was not previously mapped in detail, yet it was close to Sudbury and easily accessible.
2. The township straddles the Southern–Grenville province boundary, thereby providing an opportunity to study the metamorphic and structural history of this boundary. Results from this study could then be compared with existing metamorphic and structural studies conducted immediately to the west in Dill Township (Kwak 1968) and near Coniston (La Tour 1979), as well as near Killarney (Bethune 1993).
3. To resolve discrepancies in the Huronian Supergroup stratigraphy in the township as illustrated on regional geologic maps (Lumbers 1973; Dressler 1984a; Debicki 1990).
4. Evaluate the resource potential of garnetiferous gneisses in the township.

The present geological survey (OGS Project Number 95-031) was completed as part of an Ontario Geological Survey–Laurentian University mapping school project focussing on the metamorphic history of the Grenville Province immediately adjacent to the Grenville Front. The mapping school program is designed to encourage mapping-based research projects within Ontario, both to give students mapping experience and to allow for research beyond the scope of normal Ontario Geological Survey mapping projects. In this instance, an MSc thesis project was conducted by E.I. Murphy (née Lobanok) in conjunction with 1:20 000 scale mapping project of Street Township, by Dr. R.M. Easton of the Ontario Geological Survey. The thesis project was a detailed study of a small portion of Street Township where key geologic and metamorphic relationships were exposed. The thesis work was supervised by Dr. R.S. James of Laurentian University and Dr. R.M. Easton. Results of the mapping school project are summarized in Murphy (1999, 2001).

One week of reconnaissance mapping and sampling was conducted by R.M. Easton and E.I. Murphy in October 1995 in order to acquire preliminary geochemical and thermobarometric data for the purpose of project planning and academic training. The majority of the township was mapped during a fourteen-week period between June and September 1996 by R.M. Easton and E.I. Murphy. E.I. Murphy conducted detailed work in a roughly 4 km^2 area, in the vicinity of Timmins Creek, northeast Street Township. S.B. Buckley provided excellent field assistance to both mappers in 1996 and, in the winter of 1996 to 1997 collected thermobarometric data from several samples. Geochronology samples were collected in September 1996 by F. Corfu of the Royal Ontario Museum. Detailed mapping in the Timmins Creek area was conducted by E.I. Murphy in August to September 1996, 1997 and 1998 (Murphy 1999, 2001). A BSc thesis project focussing on orthopyroxene hornblendite bodies in and near Street Township was undertaken by L. Hubbard, Laurentian University in 1997 to 1998 (Hubbard 1998). In 1998, R.M. Easton spent roughly 5 days conducting a detailed mapping and geochemical sampling study of a metagabbronorite body in southeastern Street Township (Easton 1999a).

This report serves as a summary of the results of all of the aforementioned researchers. It is designed to complement, not duplicate, the report on the Timmins Creek area by Murphy (2001). Table 1 lists the 22 publications, exclusive of this report, that resulted from this project between 1996 and 2001. Because of the unique nature of this project, in that it involved several researchers working at different times over a five-year period, Table 2 is presented in order to provide an overview of the specific contributions made by the different researchers involved in the project.

Map P.3427 (back pocket) presents the results of the geological survey carried out during the course of this project, as outlined in Table 2, incorporating the mapping of Easton (1999a) and Murphy (1999, 2001). Geological mapping was conducted using vertical aerial photographs at a scale of 1:20 000, obtained from by the Air Photo Library, Public Information Centre, Ontario Ministry of Natural Resources. Acetate overlays were used to record data that were collected on traverses by the pace and compass method. Geology was not tied to surveyed lines. Traverses were not spaced at regular intervals, but were designed to include as many of the major outcrop areas as possible, particularly in areas of complex geology and along contacts between major rock units.

Information from mapping was plotted on Ontario Basic Mapping (OBM) 1:20 000 base maps supplied by the Ontario Ministry of Natural Resources, which were digitally combined and simplified. Recent information with respect to roads, buildings, powerlines, rock and shoreline features, were added to the resulting base map.

Reference to specific locations (e.g., photographs, samples) in the text are given in UTM co-ordinates because of the ability to pinpoint locations more precisely than by using latitude and longitude. The map area is located in UTM Zone 17T, and co-ordinates are given using the NAD27 datum. The subdivision of Street Township into lots and concessions was annulled three decades ago, consequently, reference to lots and concessions with respect to mineral occurrences is not utilized in this report.

Table 1. Summary of publications related to the Street Township Ontario Geological Survey–Laurentian University mapping school project.

Preliminary reports

Easton, R.M., Buckley, S.G., Lobanok, E. and James, R.S. 1996. Grenville–Southern province relationships in Street Township, District of Sudbury; *in* Summary of Field Work and Other Activities 1996, Ontario Geological Survey, Miscellaneous Paper 166, p.66-69.

Easton, R.M. 1996. Geology of garnetiferous gneisses in Street Township, District of Sudbury; *in* Summary of Field Work and Other Activities 1996, Ontario Geological Survey, Miscellaneous Paper 166, p.70-73.

Field trip guidebook

Easton, R.M., Davidson, A., and Murphy, E.I. 1999. Transects across the Southern–Grenville Province Boundary near Sudbury, Ontario, Guidebook #A2, Sudbury '99, Geological Association of Canada, 52p.

Table 1. Summary of publications — continued.

Final Reports

Murphy, E.I. 2001. Geology, metamorphism, and geochemistry of the Southern and Grenville province rocks in the vicinity of the Grenville Front, Timmins Creek area, near Sudbury, Ontario; Ontario Geological Survey, Open File Report 6041, 132p.

Geochronology results

Corfu, F. and Easton, R.M. 1998. Extension of the Huronian magmatic suite inside the Grenville Province: new zircon U/Pb evidence from the Grenville Front Tectonic Zone in Street Township, Sudbury region, Ontario; 44th Annual Institute on Lake Superior Geology, Proceedings, Volume 44, Part 1, p.59-60.

Corfu, F., Easton, R.M. and Murphy, E. 1998. Zircon, monazite and titanite U/Pb isotopic systematics in polymetamorphic rocks of the Grenville Front Tectonic Zone near Sudbury, Ontario; Geological Society of America, Abstracts with Program, v.30, no.6, p.A-215.

Easton, R.M. and Crabtree, D. 1999. Electron microprobe dating of metamorphic monazites: a case study from the Grenville Front tectonic zone east of Sudbury; *in* Summary of Field Work and Other Activities 1998, Ontario Geological Survey, Miscellaneous Paper 169, p.203-208.

Corfu, F. and Easton, R.M. 2000. U/Pb evidence for polymetamorphic history of Huronian rocks in the Grenville Front Tectonic Zone east of Sudbury, Ontario; Chemical Geology, v.172, p.149-171. (issue released in February 2001).

Maps

Easton, R.M. and Murphy, E.I. 2000. Geology of Street Township; Ontario Geological Survey, Preliminary Map P.3427, scale 1:20 000.

Murphy, E.I. 2001. Precambrian Geology, Timmins Creek area, Street Township; Ontario Geological Survey, Preliminary Map P.3428, scale 1:4000.

Mineral Potential

Easton, R.M. 1998. New Observations Related to the Mineral Potential of the Southern Province and the Grenville Front Tectonic Zone east of Sudbury; Ontario Geological Survey, Open File Report 5976, 28p.

Easton, R.M. 1999. PGE, Ni, Cu, and Cr potential of mafic rocks within the Grenville Front tectonic zone east of Sudbury; *in* Summary of Field Work and Other Activities 1998, Ontario Geological Survey, Miscellaneous Paper 169, p.195-202.

Preliminary geochemistry results

Easton, R.M. and James, R.S. 1997a. Revisiting the disappearance of the Huronian in the Sudbury–Crerar area: Part 1. The Amphibolite Story; Geological Association of Canada, Program with Abstracts, v. 22, p.A43.

Easton, R.M. and James, R.S. 1997b. Revisiting the disappearance of the Huronian in the Sudbury–Crerar area: Part 2. The Paragneiss Story; Geological Association of Canada, Program with Abstracts, v. 22, p.A44.

Easton, R.M. and James, R.S. 1997c. Revisiting the disappearance of the Huronian in the Sudbury–Crerar area: Insights from the Geochemistry of Amphibolites and Paragneisses, 43rd Institute on Lake Superior Geology, Proceedings, Volume 43, Part 1, p.19-20.

Preliminary thermobarometry results

Buckley, S.B., Easton, R.M., Ford, F.D. and Lobanok, L. 1997. Analysis of *P–T* conditions along the Grenville Front east of Sudbury, Ontario; Geological Association of Canada, Program with Abstracts, v.22, p.A-20.

Other results

Hubbard, L., James, R.S., Easton, R.M. and Corfu, F. 1998. Origin of metaproxenites and high-Al chromitites from the Grenville Front Tectonic Zone near Sudbury, Ontario; Geological Society of America, Abstracts with Program, v.30, no.6, p.A-96.

Murphy, E.I., James, R.S. and Easton, R.M. 1998. Revisiting the position of the Grenville Front in the Timmins Creek area, Sudbury, Ontario; Geological Society of America, Abstracts with Program, v.30, no.6, p.A-95.

Murphy, E.I., James, R.S. and Easton, R.M. 1999. Geology and metamorphic history of the Timmins Creek area, Grenville Front Tectonic Zone, Sudbury, Ontario; Geological Association of Canada, Program with Abstracts, v.24, p.89.

Easton, R.M. 1999. Paleogeography of the Huronian Supergroup in and around Sudbury: Constraints from studies of the Grenville Front Tectonic Zone; Geological Association of Canada, Program with Abstracts, v.24, p.35.

Theses

Hubbard, L. 1998. A petrographic study of Proterozoic meta-pyroxenites of the Grenville Front Tectonic Zone, Sudbury, Ontario; unpublished BSc. thesis, Laurentian University, Sudbury, Ontario, 48p.

Murphy, E.I. 1999. Geology, metamorphism and geochemistry of Southern and Grenville Province rocks in the vicinity of the Grenville Front, Timmins Creek area, near Sudbury, Ontario; unpublished MSc. thesis, Laurentian University, Sudbury, Ontario, 266p.

Table 2. Summary of the contributions made by the different members of the Street Township Ontario Geological Survey-Laurentian University mapping school project team.

Researcher and affiliation	Mapping	Geochemistry	Mineral Chemistry	Thermo-barometry	Geochronology	Thesis Supervision	Poster/Oral presentation and major field trips
S.B. Buckley (assistant to R.M. Easton 1996-1997)				data collection and analysis of regional samples and preliminary samples in Timmins Creek area (1996-1997)			GAC-MAC Ottawa'97 poster
D. Crabtree (microprobe scientist, Geoscience Laboratories)					data collection, interpretation on monazites (1998)		
F. Corfu (geochron-ologist, Royal Ontario Museum)					sample collection, data collection on zircon, monazite, titanite and interpretation (1996-1998)		ILSG'98 talk, GSA Toronto'98 talk
R.M. Easton (geoscientist, Ontario Geological Survey)	Regional mapping, Southern and Grenville provinces (1995-1996), detailed mapping south-central Street Twp. (1998), synthesis for Map. P.3427 (2001), this report (2000-2001)	sample collection and interpretation of samples throughout Street Twp (1996-2000)	synthesis for this report (2000-2001)	synthesis for this report (2000-2001)	assistant in sample collection and interpretation with Corfu (1996-1998) and Crabtree (1998)	co-supervisior of Hubbard (1997-1998) and Murphy (1995-1999). Supervised preparation of OFR 6041 and Map. P.3428 (2001)	ILSG'97 poster, GAC-MAC Ottawa'97 poster, GAC-MAC Sudbury'99 talk and field trip
L. Hubbard (BSc. thesis, Hubbard 1998)	Detailed mapping of selected unit 6 bodies in and near Street Twp. (1997)	sample collection and interpretation of selected samples from unit 6 (1997-1998).	sample collection, interpret-ation of selected samples from unit 6 (1997-1998).				GSA Toronto'98 poster
R.S. James (professor, Laurentian University)						main supervisor of Hubbard (1997-1998) and Murphy (1995-1999)	ILSG'97 poster; GSA Toronto'98 poster; GAC-MAC Sudbury'99 field trip
E.I. Murphy (MSc. thesis, Murphy 1999)	Regional mapping, Grenville Province (1996), detailed mapping in the Timmins Creek area (1996-1998)	sample collection and intreprctation of some samples from the Timmins Creek area (1996-1999)	data collection and analysis of samples from the Timmins Creek area (1996-1999)	data collection and analysis of samples from the Timmins Creek area (1996-1999)		final production of OFR 6041 and Map. P.3428 (2000)	GAC-MAC Ottawa'97 poster; GSA Toronto'98 poster; GAC-MAC Sudbury'99 talk

Abbreviations: GAC-MAC = Geological Association of Canada and Mineralogical Association of Canada; GSA = Geological Society of America; ILSG = Institute on Lake Superior Geology; OFR = Open File Report.

TERMINOLOGY

A number of terms used in the discussion of the general geology are outlined below.

Precambrian Time Scale

The Precambrian time scale as subdivided by Easton (1999b) is used. This is an updated version of the time scale used for Geology of Ontario (Ontario Geological Survey 1992a). Precambrian time is divided into 2 eons; the Archean (older than 2500 Ma), and the Proterozoic (between 2500 and 543 Ma). The Proterozoic is divided into 3 eras; Paleoproterozoic (2500 to 1600 Ma); Mesoproterozoic (1600 to 900 Ma); and Neoproterozoic (900 to 543 Ma).

Huronian Supergroup Stratigraphy

Stratigraphic subdivision of the Huronian Supergroup follows the recommendations of the Federal-Provincial Committee on Huronian Stratigraphy (Robertson, Card and Frarey 1969), as modified by Bennett, Dressler and Robertson (1991) and Debicki (1990). Figure 2 illustrates the stratigraphic succession present in the Sudbury area.

Rock Classification

Terminology for all plutonic rocks in the area follows that of Streckeisen (1976). For metamorphic rocks, mineral prefixes are listed in order of relative abundance, starting with least abundant first. Mineral abbreviations follow Kretz (1983.) The following conventions are used regarding descriptive adjectives. A *gneissic granite* is a meta-igneous rock of granitic composition. A *granitic gneiss*, a *granite gneiss*, or a *gneiss of granitic composition* may be either a meta-igneous or a metasedimentary rock. Similarly, a *tonalitic gneiss* or a *tonalite gneiss* is a gneiss of tonalite modal composition, but may be of either meta-igneous or metasedimentary origin. A *gneissic meta-arkose* is a metasedimentary gneiss of overall granitic composition.

The term metamorphic grade is used in the case where bulk-rock composition or other factors prevent a more detailed assignment of metamorphic conditions. Where metamorphic conditions can be outlined more precisely, the metamorphic facies terminology of Turner (1981) is used.

Foliation, Schistosity, Gneissosity, Cleavage

Foliation is used to describe all types of megascopically recognizable structural surfaces of metamorphic origin (Turner and Weiss 1963). Several distinguishable types of foliation include compositional layering and preferred orientation of mineral grains. Bedding and schistosity are the most common varieties of foliation in the map area. Schistosity is a planar structure in a metamorphic rock due to abundant, preferentially oriented grains, especially micas. Schistosity is accompanied by a fissility in the rock, and is best developed in micaceous rocks. Gneissosity denotes a layering of metamorphic origin, defined by the alternation of layers, streaks, or lenticles on contrasting mineralogy or texture. The streaks or lenticles may be discontinuous. Cleavage denotes a parting in the rock resulting from the parallel growth of micaceous or elongated minerals in fine- to medium-grained rocks.

Layering Thickness Terms

Layering thickness terms used in this report are listed below. These terms apply to bedded, layered and gneissic rocks.

Very thinly layered	<3 cm
Thinly layered	3 to 10 cm
Medium layered	10 to 30 cm
Thickly layered	30 to 100 cm (1 m)
Very thickly layered	1 to 3 m
Extremely thickly layered	>3 m

Migmatite Terminology

A migmatite is a heterogeneous rock composed of two or more components, one generally quartzofeldspathic in composition (leusosome or neosome) and the other more mafic in composition (paleosome or mesosome). Within the study area, such rocks are commonly layered and, in many instances, are formed by partial melting during high-grade regional metamorphism. Descriptive terminology for these rocks follows Mehnert (1969). Other related terms used herein are: metatextite - a rock resulting from moderate degrees of partial melting, in which leucosome is subordinate to mesosome; and diatextite - a rock resulting from high degrees of partial melting, and containing substantial amounts of leucosome.

Geochemical Methods and Terminology

Except where otherwise stated, all chemical analyses that appear in this report were done at the Geoscience Laboratories, Ontario Geoservices Centre, Sudbury. All chondrite-normalized rare earth element diagrams shown in this report use the chondrite normalizing values of Sun and McDonough (1989). All geochemical data collected during this study are listed in Appendix 1. Analytical methods are described in Vander Voet and Riddle (1993). Sample numbers less than 96RME-1000 refer to samples collected by R.M. Easton, whereas sample numbers greater than 96RME-3000 were collected by E.I. Murphy. Appendix 2 lists 101 geochemical analyses that were compiled from the literature for the purpose of comparing the geochemistry of Street Township rocks with possible correlative Proterozoic and Archean formations in the Sudbury area. These data were compiled from La Tour (1979), Kwak (1968), Pearson (1959), Card, Innes and Debicki (1977), and Innes (1972, 1977). Some samples collected and reported by Debicki (1990) were reanalyzed for trace elements as part of this study. These reanalyzed samples are listed in Appendix 1.

Where geochemical data are available for mafic rocks (units 1, 4, 6, 7, 8, 10, and 18; Map P.3427, back pocket), rock names based on normative mineralogy following IUGS nomenclature are given in italics for comparative purposes (e.g., melanoamphibolite = *gabbronorite*). This approach is similar to that used by Peck et al. (1995) in studying the East Bull Lake intrusion. With respect to assay data, the term "anomalous" is used with reference to background levels determined empirically by this study.

Regional Geological Setting

Figures 3 and 4 illustrate the regional geological setting of Street Township. The map area straddles the boundary between the Paleoproterozoic Southern Province and the Mesoproterozoic Grenville Province, and lies immediately east of the Sudbury Structure. Table 3 provides a summary of the major geological events and the age of the main rock units within Street Township.

The geology of Street Township cannot be fully appreciated without an understanding of the regional stratigraphic and structural elements that converge in this part of the Canadian Shield. This background information is reviewed under the following headings: 1) Proterozoic rocks in the Sudbury area, 2) major fault systems, and 3) the Grenville Front tectonic zone.

Table 3. Timing of major geological events and summary of age constraints on the main rock units present in Street Township.

Event and/or Map Unit (P.3427, back pocket)	Age Constraint (in Ma)	Comment and/or Source
Pegmatite vein emplacement (unit 25)	989±4	Corfu and Easton (2000)
Sudbury dike swarm (unit 20)	1238±4	emplaced in or along northwest-trending faults in the Southern Province, but apparently not deformed by those faults. Deformed and metamorphosed within Grenville Province. Krogh et al. (1987).
Albitization event	1701±4	U/Pb monazite, Schandl, Gorton and Davis (1994); fluid focussed along northwest-trending faults
Northwest-trending regional faults	Pre-1700, post-1850	Faults cut Sudbury Structure
Impact event and formation of Sudbury breccia (unit 19)	1850±1	Krogh, Davis and Corfu (1984)
Thrust faulting	post-F_2 pre-regional faulting	Sudbury breccia localized along these faults, suggesting they are pre-Sudbury Structure
F_2 folding	post-2200, pre-1700, pre 1850?	Pre-regional faulting, Nipissing sills folded, relationship to Sudbury Structure uncertain
F_1 folding	pre-2200	Nipissing sills appear unaffected by this folding
Emplacement of Nipissing gabbro sills (unit 18)	2219±4 to 2210±4	Corfu and Andrews (1986); Noble and Lightfoot (1992)
Huronian sedimentation	>2220 but <2460	
Huronian felsic volcanism and related metaplutonic rocks (units 9, 11)	2460±20	Corfu and Easton (2000)
Emplacement of East Bull Lake intrusive suite rocks (units 7, 8)	2475±2	L.M. Heaman (geochronologist, University of Alberta, personal communication, 1999)
Emplacement of orthopyroxene hornblendite bodies (unit 6)	2468±5	Corfu and Easton (2000)
High-grade Archean metamorphism and migmatization	2647±4	Krogh, Davis and Corfu (1984); Wodicka and Card (1995)
Emplacement ages of Archean units in the Sudbury area (units 1 to 5)	2711±7 to 2642±1	Krogh, Davis and Corfu (1984); Wodicka and Card (1995); Chen, Krogh and Lumbers (1995); Meldrum et al. (1997)

PROTEROZOIC ROCKS IN THE SUDBURY AREA

Proterozoic rocks in the Sudbury area are assigned to either the Paleoproterozoic Southern Province or the Mesoproterozoic Grenville Province. The Southern Province in Ontario comprises Paleoproterozoic metasedimentary and metavolcanic rocks of the Huronian Supergroup and gabbroic intrusions of the Nipissing gabbro suite. Also included in the Southern Province are the Sudbury Igneous Complex and the Whitewater Group; plutonic and minor volcanic rocks of the Killarney Magmatic Belt; and rocks of the Sudbury diabase dike swarm (*see* Figure 3; Bennett, Dressler and Robertson 1991).

The Huronian Supergroup (*see* Figure 2) was deposited unconformably on Archean plutonic and supracrustal rocks of the Superior Province. The lowest unit, the Elliot Lake Group, consists of both metavolcanic and metasedimentary rocks. In the Sudbury area, the metavolcanic units include tholeiitic basalts of the Elsie Mountain Formation, evolved tholeiitic basalts, dacites, and metasedimentary rocks of the Stobie Formation, and dacites and rhyolites of the ~2450 Ma Copper Cliff Formation. The latter are likely coeval with the Murray and Creighton granites (Bennett, Dressler and Robertson 1991). The metavolcanic units interfinger with, and are overlain by the Matinenda Formation in the west and the McKim Formation in the east. Geochemical data reported by Innes (1972, 1977) and Easton (1998) indicate a tholeiitic affinity for the Stobie Formation, whereas felsic metavolcanic rocks of the Copper Cliff Formation and the Murray and Creighton granites show calc-alkalic signatures.

At the base of the Huronian Supergroup in the Elliot Lake, Agnew Lake and Sudbury areas are several layered gabbro to anorthosite intrusions referred to as the East Bull Lake intrusive suite (Peck, James and Chubb 1993; James et al. 2002). These bodies have been dated at 2491-2475 Ma (Krogh, Davis and Corfu 1984), and appear to be slightly older than the rocks of the Elliot Lake Group.

Each of the three groups overlying the Elliot Lake Group (*see* Figure 2) consists of sedimentary cycles of conglomerate, mudstone, siltstone or carbonate, capped by cross-bedded sandstone (Bennett, Dressler and Robertson 1991). Conglomerate units (e.g., Ramsey Lake, Bruce and Gowganda formations) in each of the cycles have been interpreted as being glaciogenic in origin, likely deposited in a marine environment adjacent to an ice shelf. The siltstone and sandstone units are interpreted to represent deposition during warmer intraglacial or post-glacial periods in either fluvial or marine environments (Junnila and Young 1995; Fralick and Miall 1989). Huronian deposition was complete by 2220 Ma, the age of the Nipissing gabbro suite (Corfu and Andrews 1986; Noble and Lightfoot 1992).

The Huronian Supergroup has been interpreted to represent a Wilson cycle, starting from a rifting phase represented by the Elliot Lake, Hough Lake and Quirke Lake groups, followed by a passive margin sequence (Cobalt Group), and concluded by a continent-arc collision between the Superior–Southern provinces and the Wisconsin Magmatic Arc Terrane (e.g., Young 1983; Hoffman 1989; Bennett, Dressler and Robertson 1991). This collisional event at circa 1870 to 1835 Ma, termed the Penokean Orogeny, is believed to be responsible for most of the metamorphism and deformation present within the Huronian Supergroup. The scale and intensity of the Penokean Orogeny remain the subject of debate (Davidson, van Breemen and Sullivan 1992; Card 1992), in part because the Penokean Orogeny has no associated plutonism in Ontario. Riller et al. (1999) present a different view, attributing deformation and peak metamorphism of the Huronian Supergroup to the 2470 to 2220 million-year-old Blezardian Orogeny, with subsequent transpressional deformation during the Penokean Orogeny. These divergent views reflect the lack of constraints on the age of Huronian metamorphism and deformation.

The Sudbury Igneous Complex was emplaced at 1850 Ma (Krogh, Davis and Corfu 1984) and consists of a lower, ore-bearing sublayer, a main mass of norite, and an upper granophyre (e.g., Dressler, Gupta and Muir 1991). Associated with the Sudbury Igneous Complex are brecciated rocks, termed the

Sudbury breccias (e.g., Dressler, Gupta and Muir 1991), consisting of randomly oriented blocks of country rock in a fine-grained, pseudotachylite matrix. The breccias occur up to 200 km from Sudbury, but are most abundant near Sudbury. The Sudbury Igneous Complex and related rocks has been variously interpreted as originating from meteorite impact, impact-induced plutonism and volcanism, and volcanism (*see* reviews in Pye, Naldrett and Giblin 1984). The southern part of the Sudbury Igneous Complex was weakly metamorphosed by an event that also retrograded metamorphosed rocks of the Huronian Supergroup. Regional sodium and potassium metasomatism and silicification has intensely altered rocks locally within the Huronian Supergroup, especially along faults, at ~1700 Ma (Meyer et al. 1990; Gates 1991; Schandl, Gorton and Davis 1994; Easton et al. 1996; Fedo et al. 1997). Significant magmatism occurred at 1750 to 1730 Ma and again at 1500 to 1450 Ma in the Killarney Magmatic Belt (van Breemen and Davidson 1988; Davidson and van Breemen 1994; Krogh 1994).

The last major magmatic activity in the Southern Province occurred at 1240 Ma with the emplacement of the northwest-trending Sudbury diabase dike swarm (Krogh et al. 1987). This event is noteworthy, as rocks of this dike swarm can be traced across the Grenville Front into the Grenville Front tectonic zone, providing an important marker horizon (e.g., Bethune 1997).

Significant changes in thickness within the Huronian Supergroup occur east and west of a north-south line roughly coincident with the trace of the Upper Wanapitei River fault (*see* Figure 3). Debicki (1990) estimates the thickness the Huronian Supergroup in the Sudbury-Coniston area to be roughly 10 350 m, 85% of which constitutes the lower 3 groups. In contrast, east and northeast of Wanapitei Lake, the thickness of the Huronian Supergroup is roughly 6250 m, 75% of which consists of the Cobalt Group. The Elliot Lake, Hough Lake and Quirke Lake groups are all considerably thinner east of Wanapitei Lake, and the McKim and Ramsey Lake groups are apparently absent. Figure 5 summarizes these variations in stratigraphic thickness and distribution of formations. This variation in thickness and the thinning and disappearance of units along strike complicates stratigraphic analysis in Street Township.

MAJOR FAULT SYSTEMS

Upper Wanapitei River Fault

The Upper Wanapitei River fault (*see* Figure 3) has had a protracted deformation history, exhibiting at least 7 to 8 km of left-lateral movement between 2170 and 1850 Ma (Buchan and Ernst 1994), and at least 3 km of left-lateral movement post-1040 Ma (Easton and Murphy 2000). According to Easton (2000), the north-trending Upper Wanapitei River fault (Buchan and Ernst 1994) apparently divides the Archean rocks in the Elliot Lake to North Bay area into two domains, with the boundary between these domains passing through Street Township. The eastern domain, which includes the River Valley–Hagar area and the eastern half of Street Township, consists of supracrustal and metaplutonic rocks, with deeper levels in the crust being exposed, likely due to Grenville orogenesis, to the south. In contrast, the western domain, which includes western Street Township, is pluton-dominated, with deeper levels of the crust, being exposed to the east. The amount of vertical movement across the fault is unknown. Significant vertical movement would be necessary to juxtapose granulites of the Levack gneiss complex against higher crustal-level rocks to the east, however, if the Upper Wanapitei River fault re-activated an older listric fault system, then considerably less relative uplift across the fault may be present.

Murray Fault System

Significant changes in stratigraphic thickness within the Huronian Supergroup occur across some regional faults, in particular, the Murray fault system (e.g., Bennett, Dressler and Robertson 1991, and references therein). North of the Murray fault, the McKim Formation is tens of metres thick, whereas south of the fault, it probably excedes 1000 m. The thickness and facies variations across the Murray fault system suggest that the faults represent south side down, synsedimentary, growth faults that were reactivated during compression related to the Penokean Orogeny (e.g., Zolnai, Price and Helmstaedt 1984).

In addition to stratigraphic thickness variations, the Murray fault system also marks profound changes in structural style, metamorphic grade and magmatic associations (Card et al. 1972). Deformation is more complicated and of greater intensity south of the fault. Likewise, metamorphic grade is higher immediately south of the fault (amphibolite facies transitional southward to greenschist facies) than to the north (greenschist to subgreenschist facies). South of the fault, there are several 1750 Ma and younger granitoid complexes (e.g., Cutler batholith) (Davidson and van Breemen 1994), whereas, north of the fault, there are no such intrusions. Northeast of Coniston, the Grenville Front boundary fault and the Murray fault system are thought to merge into the Wanapitei fault (Davidson 1997), which can be traced by mapping into Street Township. Consequently, in Street Township, Huronian strata located west and northwest of the Wanapitei fault occur north of the Murray fault system, whereas any Huronian rocks within the Grenville Province would have originally been deposited south of the Murray fault system.

THE GRENVILLE FRONT TECTONIC ZONE

The Grenville Front tectonic zone is a region up to 30 km across lying between the Grenville Front and the Central Gneiss Belt of the Grenville Province (*see* Figure 3). Easton (1992) divided the Grenville Front tectonic zone in Ontario into 3 lithologic segments. The western segment between Killarney and Wahnapitae comprises rocks equivalent in age, geophysical signature, and rock type to the adjacent Killarney Magmatic Belt. The central segment stretches from Wahnapitae to River Valley, and contains mafic intrusive rocks of both the East Bull Lake and the Nipissing intrusive suites, as well as several types of migmatitic gneisses, likely of Neoarchean age (Easton 2000). The eastern segment, between River Valley and the Ottawa River, includes rocks mainly derived from the adjacent Superior Province.

The Grenville Front is a zone of southeast-dipping faults and mylonites and has generally been placed at the southeast limit of recognizable Southern Province rocks (e.g., Lumbers 1975; Davidson 1997). Locally, there are complications that have led to many debates concerning the identity of the Grenville Front and its distinction from other faults that intersect, merge with or are parallel to the Front (see discussion in Davidson 1997).

In central Street Township, the Grenville Front (which is coincident with the Wanapitei fault) has been displaced to the north by the younger, north-trending, Upper Wanapitei River fault by at least 850 m of sinistral and west-side-up movement (Easton et al. 1996; Easton 2000). From Jackson Lake eastward, the Grenville Front (or more precisely, the Grenville Front boundary fault) was traced by Lumbers (1973) along a zone of cataclasis separating migmatitic gneisses in the south from non-migmatitic, amphibolite facies rocks to the north. Easton (1996) and Easton et al. (1996) initially accepted this interpretation, but subsequent results from this study, including the work of Murphy (1999, 2001), have led to the conclusion that the actual trace of the Grenville Front is coincident with the Ess Creek fault located about 1 km to the north of the Grenville Front boundary fault (*see* Figure 3 and 4). It remains unclear whether the Murray fault also continues along the same lineament.

Geology

OVERVIEW OF STREET TOWNSHIP GEOLOGY

The geology of Street Township (Map P.3427, back pocket) is generalized in Figure 6. The western and northern parts of the township lie within the Paleoproterozoic Southern Province, the eastern and southern parts of the township lie within the Mesoproterozoic Grenville Province. The two geological provinces are separated by several faults that constitute the Grenville Front. Table 4 lists the rocks units present within the map area, and the relative ages of those rocks units. As previously noted, Table 3 summarizes the geological history of the area in and around Street Township and the current geochronological constraints on the timing of those events.

Easton (1996) divided the Grenville Province rocks in Street Township into 4 lithotectonic domains, oriented roughly parallel to the Grenville Front in the area (*see* Figure 6). This subdivision is still instructive, even though the nature and signficance of the domain boundaries remains unclear.

Domain 1, located along the southeastern and Timmins Creek segments of the Grenville Front (*see* Figure 6), consists of flattened, biotite-garnet, biotite-garnet-kyanite, amphibolite and garnet amphibolite gneisses, with a strong fabric oriented parallel to the Grenville Front.

Domain 2 is characterized by thin rock units exhibiting transitional type 1–type 2 interference folds, dominated by a main, possibly late, variably plunging, northeast-trending overturned antiform (*see* Figure 6). The main rock units include highly deformed, migmatitic, garnet amphibolite; and a package of mainly quartzofeldspathic, generally non-migmatitic, garnet-rich gneisses. The garnet-rich gneisses include muscovite- and kyanite-bearing varieties along with thin layers of garnet-rich mafic and garnet-gedrite gneisses, the latter featuring golf-ball size garnets. Rare feldspathic, quartzose, metapelitic and metaconglomeratic paragneisses are also present. Non-migmatitic, typically garnet-absent, clinopyroxene-bearing, weakly ophitic, amphibolite, locally displays cross-cutting relationships with the preceding 3 units. Domain 2 is the only domain that contains preserved, albeit folded and boudinaged, metadiabase dikes of the Sudbury dike swarm in addition to amphibolites that may be highly deformed equivalents of Nipissing gabbro.

Domain 3, consists of migmatitic (>20% leucosome), garnet-bearing to garnet-rich quartzofeldspathic gneisses, which wrap around large masses and enclaves of dominantly non-migmatitic, mafic, orthogneisses and rocks of Domain 4 (*see* Figure 6). These enclaves commonly possess a gneissosity at high-angle to that found in the garnetiferous, migmatitic host rocks. The migmatitic gneisses are highly folded on an outcrop scale, but lack the large-scale folds observed in Domain 2. The migmatitic gneisses may originally have been metasediments, but the protolith is obscure.

Domain 4 rocks consist of either clinopyroxene-bearing, foliated to gneissic amphibolite and anorthositic gabbro to gabbroic anorthosite that is likely equivalent to the circa 2475 Ma East Bull Lake intrusive suite or migmatitic, granodiorite to monzogranite that is 2460 million years in age.

Table 4. Stratigraphic sequence present within Street Township.

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT and PLEISTOCENE

Lake, stream and swamp deposits. Glacial deposits; sand and gravel, clay and till

UNCONFORMITY

PRECAMBRIAN

MESOPROTEROZOIC

HIGH-GRADE METAMORPHISM WITHIN THE GRENVILLE PROVINCE

Felsic intrusive rocks (unit 25)

Monzogranite to syenogranite pegmatite dikes, present only in the Grenville Province, some dikes may be Archean in age.

INTRUSIVE CONTACT

Mylonitic rocks and tectonites (unit 24)

Flattened, porphyroclastic and straight gneisses of varied composition and texture. Also includes chloritized and hematitized fault gouge.

TECTONIC CONTACT

Diatextitic gneisses (>20% leucosome)

Migmatitic quartzofeldspathic gneisses (unit 23)

Garnet-biotite gneiss, locally with mafic pods or rusty metasedimentary pods.

Intermediate to felsic migmatitic gneisses (unit 22)

Granodiorite to monzogranite gneiss, locally with mafic pods or rusty metasedimentary pods.

Mafic to intermediate migmatitic gneisses (unit 21)

Garnet-amphibolite and biotite-garnet amphibolite gneiss, locally with mafic pods or rusty metasedimentary pods.

METAMORPHIC OR TECTONIC CONTACT

Sudbury diabase dike swarm (1238 Ma) (unit 20)

Fine- to medium-grained, olivine diabase, unmetamorphosed in the Southern Province, metamorphosed and deformed in the Grenville Province.

INTRUSIVE CONTACT

PALEOPROTEROZOIC

REGIONAL SODIUM-METASOMATISM (1700 Ma) and LOW- TO MODERATE-GRADE METAMORPHISM WITHIN THE SOUTHERN AND GRENVILLE PROVINCES (AGE UNCERTAIN)

Sudbury breccia (1850 Ma) (unit 19)

Randomly oriented blocks of country rock in a fine-grained, pseudotachylite matrix, related to the formation of the Sudbury Structure, only recognized within the Southern Province

TECTONIC CONTACT

Nipissing gabbro (2219-2210 Ma) (unit 18)[4]

Fine- to medium-grained gabbro and gabbronorite, weakly metamorphosed within the Southern Province, metamorphosed and deformed within the Grenville Province

INTRUSIVE CONTACT

Huronian Supergroup (2450-2219 Ma)

Cobalt Group

Gowganda Formation (unit 17)

Conglomerate, minor siltstone. Present only in Southern Province.

Table 4. Stratigraphic sequence — continued.

Quirke Lake Group

Serpent Formation (unit 16)
Litharenite, feldspathic litharenite, minor conglomerate. Present only in Southern Province.

Espanola Formation (unit 15)
Calcareous siltstone, calc-arenite, siliceous limestone and dolostone. Present only in Southern Province.

Bruce Formation (unit 14)
Conglomerate. Present only in Southern Province.

Hough Lake Group

Mississagi Formation (unit 13)
Litharenite, feldspathic litharenite, minor siltstone. Unmetamorphosed in Southern Province, metamorphosed and deformed in Grenville Province.

Pecors Formation (unit 12)
Siltstone, minor litharenite, only exposed in subsurface. Unmetamorphosed in Southern Province, metamorphosed and deformed in Grenville Province.

DISCONFORMITY OR UNCONFORMITY

Elliot Lake Group (2470-2450 Ma)

Stobie Formation (units 10 and 11)
Mafic, intermediate and felsic metavolcanic rocks. Exposed only in Grenville Province.

INTRUSIVE CONTACT

Intermediate to felsic intrusive rocks (2470-2450 Ma) (unit 9)
Monzogranite, minor granodiorite and syenogranite, likely subvolcanic equivalent of Stobie Formation felsic volcanic rocks. Exposed only in Grenville Province, increasingly migmatitic with distance south of the Grenville Front.

INTRUSIVE CONTACT OR UNCONFORMITY?

East Bull Lake intrusive suite (2470-2490 Ma) (units 6, 7, 8)
Gabbro and gabbronorite, leucogabbronorite, melanogabbronorite, minor anorthosite, norite and orthopyroxene-bearing hornblendite. Exposed only in Grenville Province.

INTRUSIVE CONTACT

ARCHEAN

NEOARCHEAN

REGIONAL HIGH-GRADE METAMORPHISM AND MIGMATIZATION

Intermediate to felsic intrusive rocks (unit 5)
Granodiorite, tonalite, minor monzogranite and alkali-feldspar granite. Exposed only in Grenville Province.

INTRUSIVE CONTACT

Migmatitic to metatextititic gneisses (5 to 20% leucosome)

Mafic gneisses (unit 4)
Surreitic, medium grained, amphibolite and garnet amphobolite. Exposed only in Grenville Province.

Felsic to aluminous gneisses (unit 3)
Garnet-muscovite-bitoite, garnet-muscovite, garnet-biotite gneiss, muscovite gneiss, locally with retrograded garnet, kyanite-muscovite-bitite-garnet gneiss, sillimanite-muscovite-biotite-garnet, garnet-potassium feldspar-muscovite-biotite, garnet-potassium feldspar-muscovite gneiss, and garnet-gedrite gneiss. Exposed only in Grenville Province.

Biotite-garnet gneisses (unit 2)
Biotite-garnet gneiss, likely metasedimentary in origin, minor calc-silicate gneiss. Exposed only in Grenville Province.

Mafic gneiss (unit 1)
Garnet-amphibolite (possible metavolcanic). Exposed only in Grenville Province.

In northeast Street Township, metavolcanic rocks south of the Ess Creek fault and north of the Grenville Front boundary fault (Lumbers 1975) (*see* Figure 6) are correlated with the Stobie Formation of the Elliot Lake Group. Associated metasedimentary rocks near Timmins Creek are correlated with the Pecors and Mississagi formationa, and are found adjacent to 2460 Ma granitic rocks. This correlation, based on stratigraphic position and geochemical characteristics, indicates that felsic magmatism of Huronian-age to the east of Sudbury was more extensive than previously known. The Huronian Supergroup metavolcanic and metasedimentary rocks in the Timmins Creek area were metamorphosed to upper amphibolite facies during the Grenville Orogeny. In southwest Street Township, within Domain 2, a small area of metamorphosed graded wacke and subarkose are correlated with the Mississagi Formation on the basis of geochemistry.

Easton (2000) interpreted the distribution of Archean rocks in the Elliot Lake–Sudbury–North Bay area as reflecting exposure of different crustal levels, as illustrated in Figure 3. In that analysis, the exposure level of Archean rocks within the Grenville Province in Street Township reflects mid-crustal depths, as shown schematically in Figure 7.

GEOCHRONOLOGY

Geochronological constraints on the timing of events in the vicinity of Street Township are summarized in Tables 3, 5 and 6. Table 3 outlines the timing constraints on the main geological events present in Street Township. Table 5 summarizes the geochronological constraints on the timing of Archean events in the Sudbury area. Table 6 summarizes the uranium-lead geochronology results obtained by Corfu and Easton (2000) from samples collected within Street Township as part of this study.

In addition to the conventional uranium-lead dating undertaken by Corfu and Easton (1998, 2000), Easton and Crabtree (1998) experimented with using chemically determined lead, uranium and thorium concentrations, measured using an electron microprobe, to date metamorphic monazites from upper amphibolite facies schists and gneisses located in the Grenville Front tectonic zone in Street Township. An upper amphibolite facies schist (sample 96RME-0234, Table 7) had an average model age of 1070 Ma, and yielded a linear array of data points on a PbO-ThO_2* plot, giving an age of 1070 ± 50 Ma assuming an intercept through the origin and no common lead component. However, if the initial lead content of the sample was as little as 0.05 weight percent, then the sample would yield an age of 990 Ma, similar to that obtained by standard uranium-lead isotope dilution methods.

Two samples of upper amphibolite facies migmatitic gneisses (samples 96RME-0242 and 96RME-0345, *see* Table 7) yielded more scattered data. This scatter may be explained by different common lead contents of individual monazite grains or varied degrees of lead loss. The monazites studied by Easton and Crabtree (1998) were characterized by Th and U contents lower than those found in other chemically dated monazites (<5.0 and <0.4 wt. %, respectively; see Easton and Crabtree (1998 and references therein). Easton and Crabtree (1998) concluded that the inconclusive results obtained from the Street Township samples was due to in part to common lead effects that were exacerbated by the low Th and U contents.

Table 5. Correlation chart for Archean metasedimentary and high-grade gneiss domains located in the central and southern Superior Province, Ontario and Quebec. All ages in Ma.

Event	Superior Province			Southern Grenville	
	Pontiac subprovince, Quebec–Ontario (metasedimentary)	Quetico subprovince, Ontario (metasedimentary)	Elliot Lake area, Ontario (unknown type)	Levack Gneiss Complex, Ontario (high-grade gneiss)	Hagar–River Valley–Temagami area, Ontario (unknown type)
Syenite, ne-syenite	♦	♦?	no data	♦?	no data
Late, high-level granitic rocks	2632[14]	♦?	no data	2642±1[3] Cartier Granite	
Migmatization	♦	♦?	no data	2647±2[1], ~2643[2]	2647±12[7], (Ingall Lake batholith)
Granulite facies metamorphism	♦	2650±2[11], 2651±3[11]	2641, reset titanite[1]	2648±1[2]	
Pegmatite	♦	2653+3/–4[10]	no data	No data	2650±4[5], 2660[6]
Monzodiorite, syenite, ± ne-syenite	♦	2671±2[10], 2665±2[10], 2677±5[15]	2665±2, Parisien Lake syenite[1]	2657±3[2]	younger than migmatization of tonalite and paragneiss
Pegmatite	~2668[13], 2663±1[13]	♦	♦	♦	♦
Synmetamorphic tonalite-granodiorite plutonism	♦	2669±3[9]	2676±11[16]	2681-2669[2]	2669±4[4] (Tilden trondhjemite)
Migmatization and/or granulite facies metamorphism	~2665-2677	2665-2680[8,10] 2661±1[11]	no data	2661±1[2]	no data
Monzodiorite, syenite, pegmatite	2685±3[13], 2681±2[13], 2680±1[13], 2686[14], 2678[14], 2669[14]	♦	♦	♦	♦
Tonalite-granodiorite plutonism	2673±4[13] to 2695±2[13]	2688±4[12], 2689±2[9], 2687±19[10]	no data	2681-2669[2]	2678-2683[4] (Warren trondhjemite)
Early tonalite-granodiorite plutonism	♦?	♦?	2697±12[16]	2711±7[1]	2730±2[4] (Ingall Lake batholith)
Youngest detrital zircon in paragneiss	2698, 2696, 2694, 2688, 2687, 2677[13, 8] (Pontiac, Cadillac, Timiskaming groups)	2690, 2692[8,9], 2687[10]	not applicable?	not applicable	no data
Paragneiss provenance	3029, 2980, to 2760, most <2725[13, 8]	3350, 2900, 2700[12,10]	not applicable?	not applicable	no data

[1] Krogh, Davis and Corfu 1984; [2] Card and Wodicka in press, Wodicka and Card 1995; [3] Meldrum et al. 1997; [4] Chen, Krogh and Lumbers 1995; [5] Krogh 1994; [6] Krogh and Davis 1970; [7] Steiger and Wasserberg 1969; [8] Davis 1992; [9] Zaleski, van Breemen and Peterson 1999; [10] Percival and Sullivan 1988; [11] Pan, Flett and Heaman 1998; [12] Davis, Pezzutto, and Ojakangas 1990; [13] Mortensen and Card 1993; [14] Machado et al. 1991; [15] Kwon, Tilton and Grunenfelder 1989; [16] Prevec 1993. ♦ event not present, ♦? event may not be present.

Table 6. Summary of U/Pb geochronology results from Street Township *from* Corfu and Easton (2000).

Sample number and rock type	Older zircon population	Metamorphic zircon and/or titanite	Grenvillian metamorphic zircon	Grenvillian titanite	Grenvillian monazite	Grenvillian rutile	Grenvillian apatite
C-96-5, paragneiss (96RME-242) 8.1 kilobars, 685°C (S of GFBF)	Archean detrital grains	Discordant metamorphic zircon circa 1720 Ma	Nearly concordant 992±8 Ma*		Conordant 989±4 Ma*, best estimate of age of metamorphism	Slightly discordant 973±4 Ma*	959±12 Ma+
C-96-6, schist (96RME-3112) 7.4 kilobars, 665°C (N of GFBF)	Archean detrital grains				987±3 Ma* 982±1 Ma^, best estimate of age of metamorphism	974±4* Ma	949±10 Ma+
C-96-7, granite (N of GFBF)	2460±20 Ma, upper intercept, best estimate of emplacement age	Intercept, 1720 Ma metamorphic titanite					
C-96-3, migmatitic granite gneiss (S of GFBF), same unit as C-96-7)	2475+25/–10 Ma, upper intercept, best estimate of emplacement age	1720+36/–19 Ma, metamorphic titanite, upper intercept	Concordant 987±9 Ma*	Lower intercept, 977±8 Ma			932±6 Ma+
C-96-2, leucosome in migmatitic granitic gneiss in same outcrop as C-96-3			Concordant, 995±3 Ma*, best estimate of emplacement age (possible inheritance) 987±3 Ma^	987±9 Ma*	Concordant 995±3 Ma*, best estimate of emplacement age (possible inheritance) 987±3 Ma*,^		
C-96-1, late pegmatite cutting migmatitic granitic gneiss in same outcrop as C-96-3			989±2 Ma*, best estimate of emplacement age	983±5 Ma*, pale titanite			
C-96-4, orthopyroxene hornblendite	2468±5 Ma, upper intercept	1471±10 Ma, upper intercept, metamorphic zircon	Concordant, 1052±19 Ma, small grains, low U content				

* oldest $^{206}Pb/^{207}Pb$ age, ^ average $^{206}Pb/^{207}Pb$ age, + $^{206}Pb/^{238}U$ age; GFBF, Grenville Front boundary fault

Table 7. Summary of U/Th/Pb chemical ages from Street Township (*after* Easton and Crabtree 1998).

Sample	Average Model Age	Regression Age through origin	Slope, line through origin	Regression Age with intercept	Slope and intercept	Conventional U/Pb age (Table 5)
96RME-0234	1070 Ma	1245 Ma	0.0539	1070 Ma	0.046, 0.03	986±2 Ma
96RME-0242	1873 Ma	2128 Ma	0.0942			986±2 Ma
96RME-0242	1136 Ma	1310 Ma	0.0568			
96RME-0345	1699 Ma	1985 Ma	0.0875	1791 Ma	0.077, 0.037	

PRECAMBRIAN

Neoarchean

MIGMATITIC TO METATEXTITIC GNEISSES

Mafic Gneisses (Unit 1)

Two main varieties of mafic gneiss occur in the Grenville Province in Street Township, migmatitic garnet amphibolite with greater than 5% garnet (unit 1a, Photo 1) and migmatitic garnet amphibolite with less than 5% garnet (unit 1c). These rock units are interlayered on an outcrop-scale with layers ranging in thickness from 1 to 5 m. Both varieties typically contain between 5 to 15% leucosome. Some varieties of unit 1a are characterized by white-weathering quartz-plagioclase tails developed in pressure shadows around the edges of the garnets, however, it is unclear as to wehether or not this variety of unit 1a is a seaparate mappable unit or simply reflects different tectonic conditions. In addition, in some areas, the amount of leucosome is in the 20% range, but it is not known if these leucosome-rich varieties reflect distinct units (i.e., reflecting protolith composition) or simply increased anatexis.

Mafic gneisses are present in Domains 1, 2 and 3 of the Grenville Province, but are best exposed within Domain 2 (*see* Figure 7) where they are thickly interlayered with biotite-garnet gneisses. In a few localities, relict pillows (unit 1e, Photo 2) may be present within the mafic gneisses. The heterogenity of the mafic gneisses on an outcrop scale (Photo 1); the interdigitating interlayering with rocks of unit 2 and 3; and the possible presence of pillows within the gneisses are all consistent with an extrusive origin for the mafic gneisses of unit 1.

The chemistry of the mafic gneisses are illustrated in Figures 8 to 10 and analytical data are listed in Appendix 1. Mafic gneisses are tholeiitic and plot in the high-iron tholeiite field (Figure 8) and in the ocean-floor and calc-alkalic basalt fields on trace element discrimination plots. Rare earth element plots (Figure 10a) show a change from flat patterns at roughly 10 times chondritic abundances to light rare earth element (LREE) enriched patterns with small negative Eu anomalies. Data from La Tour (1979) collected from similar amphibolites to the southwest show similar major and rare earth element compositions (*see* Figure 8 and 10b). Mafic gneisses are distinct from the Stobie Formation basalts of the Huronian Supergroup (*see* Figure 8), but it is possible that they could be equivalents of the Elsie Mountain Formation that also contains high-iron tholeiitic basalts. The lack of trace and rare earth element data on the Elsie Mountain Formation hampers a more definitive comparison. The geochemical data shown in Figures 8 to 10 are also compatible with the mafic gneisses being derived from a Neoarchean metavolcanic sequence. Such an interpretation is supported by the fact that the mafic gneisses are older than the East Bull Lake intrusive suite.

Biotite-Garnet Gneisses (Unit 2)

Unit 2 consists of fine- to medium-grained, migmatitic biotite-garnet gneiss. Quartzofeldspathic leucosome consitutes 10 to 25% of the rock. Garnet content varies from 5 to 15% (unit 2a), but garnet-poor (unit 2b) and garnet- rich (unit 2c, g) units are also present. Unit 2h represents outcrops where rocks of unit 2a and unit 1a are thickly interlayered. Some varieties contain mafic (unit 2d) or metawacke pods

(unit 2e) ranging in size from 50 to 500 cm. These pods may represent remnants of boudinaged layers within the biotite-garnet gneiss. A few 1 to 5 m thick layers of fine-grained, diopside-bearing, quartzofeldspathic gneiss (unit 2f), possibly calc-silicates, are interlayered within unit 2a. Biotite-garnet gneisses mainly occur within Domain 2 in close association with the mafic gneisses (unit 1).

Geochemical data (Figures 11 to 16) are inconclusive with respect to the protolith of the biotite-garnet gnesses (unit 2) and it is possible that this unit may represent more than one protolith. The gneisses could represent intermediate composition metavolcanic rocks, immature metasedimentary rocks (i.e., greywackes) or volcaniclastic metasedimentary rocks. The geochemical data from this study (unit 2 samples, Appendix 1) and from the literature (Appendix 2) clearly indicate that rocks of unit 2 have no obvious counterpart within either metasedimentary or metavolcanic rocks of the Huronian Supergroup (*see* Figures 11 to 16). Iron content in the biotite-garnet gneisses are considerably higher than those present within Huronian Supergroup metasedimentary rocks and alumina contents are higher than those found in Huronian Supergroup metavolcanic rocks (*see* Figure 12 to 15). If the gneisses are metavolcanic or metavolcaniclastic rocks then they range in composition from tholeiitic andesite to tholeiitic dacite.

The garnet-rich gneisses of unit 2 could represent a hydrothermally altered metavolcanic sequence, similar to the rocks found near the Geco Mine at Manitouwadge (e.g., Zaleski et al. 1995) (Figures 9c, 9d). Gossans associated with garnetites in unit 2 contain minor enrichments in copper and lead (150 to 400 ppm and 30 to 50 ppm, respectively). In thin section, garnet-kyanite gneisses in unit 2 contain older and younger generations of kyanite and garnet, suggesting that the gneisses may have recrystallized from a rock of similar composition and mineralogy. Thus, Domain 2 may be a good target for base metal mineralization, in addition to being the best area for further exploration for garnet and kyanite.

Felsic to Aluminous Gneisses (Unit 3)

The main difference between the biotite-garnet gneisses (unit 2) and the felsic gneisses (unit 3) is that the felsic gneisses (unit 3) contain more quartz (Photo 3) and are muscovite-rich, with some units containing very little or no biotite. In addition, the felsic gneisses show evidence of more compositional layering within outcrops, which may represent relict bedding. The felsic gneisses (unit 3) contain smaller amounts of leucosome than the biotite-garnet gneisses (unit 2). Garnet content in the felsic gneisses is the same or may exceed garnet content in the biotite-garnet gneisses. In fact, most of the more prospective garnet horizons within Street Township occur in the felsic gneisses (unit 3).

A distinct subset of the felsic gneisses (units 3d, 3e) are aluminosilicate-bearing. Kyanite is the main aluminosilicate mineral observed in the field, however, in thin section kyanite is typically rimmed by, or partly recrystallized to, sillimanite. It is possible that many muscovite-rich gneisses (units 3a, 3b, 3c) may have reached metamorphic conditions above the muscovite-breakdown reaction resulting in the formation of potassium feldspar and sillimanite at the expense of muscovite. Subsequently, this reaction reversed itself during the waning of peak metamorphic conditions, leading to the development of muscovite and the destruction of sillimanite. Potassium feldspar in these rocks is in chemical disequilibrium with other metamorphic minerals and is suggestive that this process may have occurred.

The felsic gneisses (unit 3) may also represent a variety of protoliths. As first noted by Easton (1996), some felsic gneisses have a chemical composition suggesting derivation from altered dacitic to rhyolitic rocks, whereas some rocks have chemical compositions more compatible with derivation from feldspathic litharenites or subarkosic rocks (Figure 9b). Scenarios whereby the garnet-rich gneisses of unit 2 and 3 are paragneisses derived from the Huronian Supergroup, or a metamorphosed regolith and paleosol developed on the Archean during the Early Proterozoic, are not supported by mapping or geochemistry.

Mafic Gneisses (Unit 4)

Migmatitic amphibolite and garnet-amphibolite of unit 4 differ from compositionally similar rocks of unit 1 because they have a more homogeneous appearance in outcrop and have a distinctive surreitic texture (Mehnert 1969), or pod-like distribution of leucosome, texture as illustrated in Photo 4. Leucosome layers within the unit 4 mafic gneisess can become flattened with increasing deformation which makes it more difficult to separate mafic gneisses of unit 4 from mafic gneisses of unit 1. Mafic gneisses of unit 4 occur mainly as ovoid masses within Domain 2 and they may represent metamorphosed intrusions based on their homogeneous character and form. Mafic gneisses (unit 4 samples, Appendix 1) are tholeiitic, and range between basalt and andesite in bulk rock composition. The mafic gneisses of unit 4 are broadly similar in chemical composition to the mafic gneisses of unit 1. Garnet content in unit 4 mafic gneisses varies considerably within an outcrop and can range from 5 to 20%. Garnet is commonly found concentrated along fractures or in distinct zones that may indicate areas of more intense hydrothermal fluid flow.

INTERMEDIATE TO FELSIC INTRUSIVE ROCKS (UNIT 5)

Four small (<750 m across) bodies of foliated, grey weathering, fine- to medium-grained garnet biotite granodiorite to diorite occur in the Grenville Province east of the Upper Wanaiptei River fault in Street Township. All 4 bodies are found in association with diatextitic gneisses of unit 22 or 23, although the intrusive rocks (unit 5) themselves are non-migmatitic.

Only 2 bodies were sampled for geochemistry (samples 96RME-0080 and 96RME-0164, Appendix 1). The 2 bodies exhibit different chemical signatures, both in major and trace elements. Although the difference between the 2 bodies may simply be copositional, it is also possible that rocks of more than one age may be represented by this map unit. This is because sample 96RME-0080 shows compositional similarities to Paleoproterozoic gneissic granite of unit 9, on the basis of Al_2O_3, Ba, Zr, and Y contents as well as REE pattern. Sample 96RME-0080 is peraluminous, slightly alkalic, and consistently lies in the within-plate granite field on discrimination plots (e.g., Pearce, Harris and Tindle 1984). In contrast, sample 96RME-0164 is tholeiitic and distinct from other intrusive units within Street Township, and falls within the field of volcanic-arc granites (e.g., Pearce, Harris and Tindle 1984). Sample 96RME-0164 has some characteristics in common with Neoarchean biotite diorites present in the Grenville Province within Dana and Crerar townships (Easton 2000) and may be related to a Neoarchean intrusive event.

RELATIVE AGE OF THE GNEISSIC ROCKS OF UNITS 1 TO 5

The assignment of gneisses of units 1 to 5 to the Neoarchean, rather than the Proterozoic, is based on the following field observations:

1. Rocks of unit 7 (and 8) are incorporated as rafts within granitic gneisses of unit 9, the latter dated at circa 2460 Ma by Corfu and Easton (2000). This is consistent with assignment of these rocks to the circa 2475 Ma East Bull Lake intrusive suite and would make rocks intruded by units 7, 8 or 9 Archean in age.
2. Non-migmatitic melanoamphibolite of unit 7 cuts migmatitic amphibolite of unit 4 and migmatitic garnetiferous amphibolite of unit 1. This implies migmatization of both units 1 and 4 occurred prior to circa 2475 Ma which is the age of the East Bull lake intrusive suite to which unit 7 is assigned. Regional correlation with other Archean rocks in the Sudbury region places the best estimate of this

migmatization event at approximately 2647 Ma (Easton 2000). As rocks of units 2 and 3 are interlayered with rocks of unit 1, these two units are also, by inference, Neoarchean in age.

3. The rare earth element (REE) patterns for felsic gneisses rocks of unit 3 have no Eu anomalies and low heavy rare earth element (HREE) abundances which is typical of Archean, not Proterozoic, metasedimentary rocks (e.g., Taylor and McLennan 1985).

In Figure 7, the stratigraphic position of rocks in the Southern Province and in Domains 1 and 2 of the Grenville Province is illustrated. In this model, the rocks of units 1 to 5 correspond to a mid- to upper crustal level that represents the basal portion of a greenstone belt succession. This crustal level also appears to be a favourable horizon for emplacement of mafic intrusive rocks of the East Bull Lake intrusive suite (Easton 2000). If this model is close to being correct, then it suggests that a change in crustal exposure level of roughly 5 km occurs across the Grenville Front in the Street Township area.

The relationship between migmatitic rocks of units 1 to 4 and units 21 to 23 are more problematic, especially since rocks of units 1 to 4 are most commonly found in Domain 2 of the Grenville Province with units 21 to 23 being most abundant in Domain 3. As illustrated in Figure 17, there are 2 distinct scenarios that can explain the distribution of these units within the study area. In the first scenario (Figure 17a), units 1 to 4 and units 21 to 23 represent two discrete rock sequences, likely of different ages, which are tectonically juxtaposed by a cryptic thrust fault. In this scenario, rocks of units 1 to 4 represent Archean rocks of the Superior Province that were uplifted during the Grenville Orogeny, whereas rocks of units 21 to 23 could range in age from Archean to Neoproterozoic, and could be transported a considerable distance relative to the adjacent Superior Province. In the second scenario (Figure 17b), units 21 to 23 represent migmatitic equivalents of units 1 to 4, likely formed during the Mesoproterozoic Grenville Orogeny, with the Domain 2–3 boundary representing the position of the migmatite front.

Paleoproterozoic

EAST BULL LAKE INTRUSIVE SUITE (UNITS 6, 7, 8)

The East Bull Lake intrusive suite consists of several bodies of dominantly gabbronorite to gabbroic anorthosite composition that occur in both the Southern and Grenville provinces between Elliot Lake and the Ottawa River (*see* Figure 4). The three largest bodies are the River Valley intrusion (Grenville Province) and the East Bull Lake and Agnew Lake intrusions (Southern Province). All were emplaced at ~2475 Ma (Krogh et al. 1984; Heaman in Easton et al. 1999). Smaller bodies include the Drury, Falconbridge, May, Street and Wisner township intrusions. Collectively, these intrusions have been referred to as the East Bull Lake intrusive suite (EBL suite) (e.g., Easton 1999a; James et al. 2002).

Rocks of the East Bull Lake intrusive suite in Street Township are subdivided into three main units on Map P.3427 (back pocket):

1. Unit 6: orthopyroxene hornblendite (*olivine orthopyroxenite* and *olivine websterite*) which occurs as small (<1 km in diameter) bodies throughout the area (Photo 5).
2. Unit 7: non-migmatitic amphibolite, metagabbro, metagabbronorite and metanorite present as small to medium-size bodies throughout the map area (Photo 6).
3. Unit 8: non-migmatitic gabbroic meta-anorthosite and anorthositic metagabbro (*gabbroic anorthosite, anorthositic gabbro, leuconorite)* (Photo 7).

Rocks of unit 6, 7 and 8 are intimately associated in an intrusive body located in southwest Street Township and referred to as the Street metagabbro. Units 7 and 8 are correlative with the ~2475 Ma River Valley intrusion on the basis of similarity in rock types, relative age relationships, and on-strike proximity to mapped parts of the River Valley intrusion. Unit 6 is also considered to be related to the East Bull Lake intrusive suite based on U/Pb geochronology (Corfu and Easton 1998, 2000) and the presence of similar hornblendite and orthopyroxene hornblendite layers within the Street metagabbro. The distribution of rocks corresponding to unit 8 are accurately represented on the regional geology map of the area (Lumbers 1973), but this is not always the case for rocks of unit 7. This discrepancy largely reflects the difficulty in separating mafic rocks of units 1, 4, 7 and 18 (Nipissing gabbro) during regional mapping.

Unit 7 is shown as a separate unit on the map (Map P.3427, back pocket) due to difficulties in assigning non-migmatitic mafic rocks of gabbronorite composition to unit 7 or unit 18 (Nipissing gabbro) when these rocks occur isolated from rocks of unit 6 or 9 (even when geochemical data are available). Metamorphosed Nipissing gabbro sills exhibiting typical "Nipissing chemistry" (Easton and James 1997a, 1997c) can be reliably separated from rocks of unit 7. This cannot be done where Nipissing sills exhibit the high magnesium chemistry typical of many Nipissing sills in the Southern Province in the Sudbury region (e.g., Easton and James 1997a, 1997c). In hand specimen, rocks of unit 7 typically contain greenish-pyroxene grains and black hornblende, whereas amphibolite of Nipissing gabbro (unit 18) does not contain pyroxene. From an exploration standpoint, both high magnesium rocks of the Nipissing and East Bull Lake intrusive suites are favourable targets for magmatic nickel-copper-platinum group element (PGE) sulphide mineralization which is a reason for clearly illustrating the distribution of these rocks on map P.3427 (back pocket).

Orthopyroxene Hornblendite Bodies (Unit 6)

Orthopyroxene hornblendite of unit 6 consists of several small (50 to 500 m across), generally ovoid bodies composed of large orthopyroxene (bronzite) phenocrysts ranging from 0.5 to 5 cm in length and hosted in a fine-grained matrix of green acicular amphibole. To date, these bodies have only been observed within the Grenville Province, although some occur within 100 m of the Grenville Front (Map P.3427, back pocket). The bodies are not restricted to Street Township and occur to the east in Loughrin and Henry townships and to the south in Dryden and Awrey townships (R.M. Easton, unpublished data).

Regionally, these bodies exhibit 2 types of contact relationships, although all of the Street Township bodies are of the first type. The first type occur near sharp, possibly modified igneous contacts between metagabbroic and metaleucogabbroic rocks of the East Bull Lake intrusive suite (units 7 and 8) and their host gneisses (units 1 to 5). Bodies of this contact type appear to have been emplaced into pre-existing embayments along the metagabbro-gneiss contact. The second type occur within deformation zones characterized by flattened gneissic rocks.

Large glacial erratics of orthopyroxene hornblendite (unit 6), some up to 6 m across, are common in Street Township. The erratics are generally found within several hundred metres of observed bodies, or in areas where bodies may be hidden beneath overburden. They also occur at the contact of the Street metagabbro (units 7 and 8).

The field term for these rocks, orthopyroxene hornblendite, is based on the dominant mineral phases observed in hand sample for these rocks. Some of the better preserved bodies contain relict olivine grains. Mesonorm calculations suggest a metamorphic mineralogy dominated by pyroxene and amphibole consistent with the observed mineralogy in the field. CIPW normative calculations for these rocks suggest a primary mineral assemblage dominated by olivine (4 to 22%), hypersthene (32 to 62%),

diopside (3 to 22%) and calcic plagioclase (13 to 21%). The CIPW normative mineralogy suggests that these rocks were originally olivine gabbronorites or olivine websterites, depending on whether they contained moderate, or only minor amounts of plagioclase, respectively.

Orthopyroxene hornblendite bodies near the Grenville Front contain euhedral bronzite grains up to 5 cm long. The bronzite grains become subrounded to rounded and overall grain size decreases with increasing distance from the Grenville Front. Similar observations can be observed from the margin to the core in some of the small hornblendite bodies. This change in bronzite form with increasing distance into the Grenville Province can be attributed to greater degrees of metamorphic recrystallization toward the interior of the orogen.

Mineralogically, the orthopyroxene crystals in the bodies are complex and represent primary phenocrysts that recrystallized during regional metamorphism. Evidence that these crystals were primary phenocrysts comes from the presence of zircon and chromite inclusions within the bronzite grains. Both types of inclusions contain well-developed cores and rims. In the case of the zircon grains, subrounded cores are surrounded by euhedral fractured rims. The cores yield a U/Pb age of 2468±5 Ma, whereas the rims yield an age of 1471±10 Ma (Corfu and Easton 2000; *see* Table 6). Chromite cores are rimmed by iron chromite that typically forms only during regional metamorphism (Deer, Howie and Zussman 1966). Small euhedral zircons are also present in the fine-grained amphibole matrix and yield an age of 1052±19Ma (Corfu and Easton 2000; *see* Table 6).

Mineral chemistry data on the matrix amphiboles indicate that they are magnesium hornblende, tremolite, cummingtonite and magnesium cummingtonite. The amphiboles occur both as individual grains and complexly exsolved and intergrown grains. Olivine grains from a body located near the Grenville Front have compositions of Fo_{73}. Orthopyroxene compositions lie in the bronzite field and are magnesium-rich (En_{75-80}).

Prior to 1998, orthopyroxene hornblendites had only been observed along the contact between anorthositic metagabbro or metagabbro and country rocks. Easton (1999a) reported the presence of hornblendite layers within the Street metagabbro that were compositionally identical with the orthopyroxene hornblendites (compare samples 98RME-0055 and 98RME-0049, Appendix 1). This observation further supports the previously observed spatial association between unit 6 and other members of the East Bull Lake intrusive suite (units 7 and 8), and is consistent with U/Pb zircon geochronology (Corfu and Easton 1998, 2000) indicating that the hornblendites are the same age as the East Bull Lake intrusive suite.

GEOCHEMISTRY

Geochemistry of 5 separate bodies in this study shows only a limited compositional range in major element chemistry (Appendix 1). The SiO_2 content of the unaltered orthopyroxene hornblendites ranges from 46.0 to 50.5 weight percent which is unusually high given the corresponding MgO content of 21.0 to 27.0 weight percent. Figures 18 to 20 briefly summarize the chemistry of these rocks. In Jensen plots in Figures 18b and 8b, the orthopyroxene hornblendites plot as a cluster in the peridotitic komatiite field although there is no evidence to suggest that these rocks were extrusive. Plots of Ti versus Cr and Cr-Ni (not shown) are consistent with these rocks being crystallized from layered mafic sills. For comparison purposes, Figure 19 also shows data for amphibolites that are probable Huronian mafic metavolcanic rocks from the Street Township area (samples 96RME-0123, 96RME-0447, 96RME-3004, Appendix 1), which lie in the field of Stobie Formation samples from the Sudbury area.

Figure 20, a REE plot, shows that the orthopyroxene hornblendites plot in 2 distinct groups, one with a relatively flat, 10 times chondrite pattern with a negative Eu anomaly, and the other with moderate

LREE enrichment (to 60 times chondrite) with no Eu anomaly. The hornblendite samples from the Street metagabbro plot in the LREE enriched group. Olivine gabbronorites and pyroxenites from the River Valley intrusion also exhibit a split into 2 similar REE groups (R.M. Easton, unpublished data, 2000) further supporting the connection between orthopyroxene hornblendites of unit 6 and the East Bull Lake intrusive suite. REE contents of the 10 times chondrite group are similar to, or higher than, those observed in gabbronoritic rocks of the Street metagabbro. The REE content and high silica content of the orthopyroxene hornblendites suggest the orthopyroxene hornblendites do not represent primitive rocks of the East Bull Lake intrusive suite.

All 8 unaltered orthopyroxene hornblendite samples contain from 2900 to 4700 ppm Cr and 750 to1000 pm Ni. Copper content is generally low (Appendix 1) although sample 96RME-0041 contains 160 ppm Cu. Chromium is present as chromium-spinel, iron-chromite and chromite and is concentrated within the olivine and orthopyroxene crystals present in these rocks. The orthopyroxene hornblendites differ from other rocks of the East Bull Lake intrusive suite in their high chromium and nickel contents, as listed above. One explanation for this difference is that precipitation and removal of pyroxene from the primary magma (possibly by crystal settling) increases the silica content of the melt. The increase in silica would move the composition of the melt away from the olivine-chromite cotectic into the field of chromite and lead to the co-precipitation of bronzite and chromite. This process, in conjunction with olivine precipitation, would effectively strip the primary magma of much of its chromium and nickel leaving rocks of the East Bull Lake intrusive suite with low chromium and nickel contents.

Chromium numbers of the orthopyroxene hornblendites are 20 to 38 and magnesium numbers are 78 to 82. The bodies have chemical affinities to high-aluminum chromitite from ophiolitic complexes, most notably, chromium number less than 50, TiO_2 greater than 0.2 weight percent, CaO greater than 1.5 weight percent, and Al_2O_3 greater than 1.2 weight percent. High aluminum chromitites are found in back-arc spreading and rifting tectonic environments that are consistent with previous suggestions of a rift-setting for the lower Huronian Supergroup (e.g., Bennett, Dressler and Robertson 1991).

STINSON BODY A

Hubbard (1998) conducted a detailed study of an orthopyroxene hornblendite body, which she termed "Stinson body A", located in southwestern Street Township. Figure 21 is a detailed map of the body, based on Hubbard's (1998) study. "Stinson body A" is located less than 250 m south of the Grenville Front and contains the most lithological variation observed to date by the senior author in the orthopyroxenite hornblendite bodies he has observed. A second, smaller body, "Stinson body B" is located 100 m north of "Stinson body A", and was the source of the geochronological sample of unit 6 that was collected by Corfu and Easton (2000) and dated at 2468±5 Ma.

As illustrated in Figure 21, Hubbard (1998) noted several different units within the body. These basically fall into 3 main groups: 1) textural and mineralogical variations of orthopyroxene hornblendite including varieties containing olivine, magnetite and elongate to radial orthopyroxene grains; 2) anthophyllite-rich rocks, either as a schistose unit or as a dike-like body with radiating crystals, that are compositionally similar to the orthopyroxene hornblende and likely formed through alteration of the unit; and 3) altered rocks, including the "blackwall" alteration present along the northeast contact of the body and the silicified zone in the western part of the body. In general, the east part of "Stinson body A" is less altered than the west part.

The northeast contact of the body, which is in contact with migmatitic gneiss (unit 23) and a nearby granitic gneiss body of unit 9, may be a primary igneous contact where a black, biotite-hornblende "blackwall" alteration unit ranging from 3 to 6 metres in thickness is preserved (*see* Figure 21). Chemically, the "blackwall" is similar in most major elements to typical orthopyroxene hornblendite

(compare analyses H98-103 and H98-409, Appendix 1), particularly elements such as SiO_2, TiO_2, Al_2O_3 and MgO. However, the "blackwall" is characterized by significant additions of K_2O, Ba, and Rb. The southeast contact of the body consists of a fine-grained, foliated amphibolite, compositionally similar to the typical orthopyroxene hornblendite and may represent a chill margin at the contact.

The southwest contact of the body has a tail-like form (*see* Figure 21) extending to the southwest and consisting of very thinly layered anthophyllite schist. The anthophyllite schist is chemically similar to typical orthopyroxene hornblendites (compare analyses H98-202 and H98-409, Appendix 1) in all key oxides and trace elements (TiO_2, Al_2O_3, MgO, Cr, Ni) although it does contain much higher SiO_2. Consequently, it is interpreted that the anthophyllite schist is an altered equivalent of the orthopyroxene hornblendite. The form of the anthophyllite schist is consistent with it representing a feeder dike to the main part of "Stinson body A". The presence of other altered rocks stratigraphically (?) above the anthophyllite schist (i.e., the silicified zone and the sub-unit containing secondary bronzite crystals with a radiating form) (*see* Figure 21) suggests that the west part of the body was affected by more intense alteration than the east half. Whether this alteration was syn- to post-emplacement or occurred during regional metamorphism has not been determined.

Gabbronoritic and Leucogabbronoritic Rocks (Units 7 and 8)

Leucogabbronoritic rocks of unit 8 are generally restricted to the Street metagabbro body located in southeast Street Township, although larger masses of unit 8 occur in Loughrin Township along the east border of Street Township. In contrast, small bodies of gneissic gabbronorite and melagabbronorite of unit 7 occur throughout Street Township within the Grenville Province in Domains 2 and 3. Some of these smaller bodies may represent large dikes or sills that intruded the Neoarchean country rocks but which were subsequently deformed and metamorphosed during the Grenville Orogeny.

Individual bodies and masses of gabbronoritic rocks of unit 7 consist of dark green to black weathering, fine- to medium-grained gneissic amphibolite locally containing small, green pyroxene grains in addition to ubiquitous black hornblende. Leucosome is rare to absent in these rocks. Relict ophitic or diabase texture is rarely observed. Plagioclase content is difficult to estimate on either weathered or fresh surfaces in contrast to the moderate-magnesium rocks of the Nipissing gabbro intrusive suite (unit 18) present within the Grenville Province. Contacts with country rocks, generally with mafic gneisses of unit 4, are sharp and cut across the migmatitic layering present in the mafic gneisses. Many outcrops exhibit very thin layering subparallel to the regional fabric which may represent relict compositional layering. The origin of this layering is not known.

STREET METAGABBRO

The largest area of rocks of the East Bull Lake intrusive suite are located in southeast Street Township (Map P.3427 back pocket), and occur in the Street metagabbro, a roughly 2.5 km long by 1 km wide body. The body has a generally crescentic, dome shape (Figure 22a) reflecting a type-2 fold interference pattern (Ramsay 1967) resulting from the folding of an early recumbent fold about a steeply inclined axis. In addition, the Street metagabbro is cut by several north-northeast-striking faults. The north contact of the body is probably tectonic and characterized by intense shearing within both the anorthositic metagabbro and country rocks. In contrast, the south contact is sharp and juxtaposes anorthositic metagabbro against migmatitic (surreitic texture) amphibolite and quartzofeldspathic gneiss. In addition, there is a 300 to 400 m wide zone south of this contact, referred to as the "border zone", that consists of thinly layered melanoamphibolite (*gabbronorite*) which cuts surreitic amphibolite and quartzofeldspathic gneiss. This "border zone" may represent a feeder dike system to the Street metagabbro since the melanoamphibolite is indistinguishable from that in the main mass of the body.

Figure 23 is a composite section through the metagabbro body and shows the main units present within the intrusion. Foliated anorthositic metagabbro (unit 8b) and gabbroic meta-anorthosite (unit 8a) comprise the lowermost unit (lower series) within the intrusion with a maximum thickness of roughly 150 m. Variation in plagioclase content within this unit may reflect primary layering in the body. This layering is cut by 50 to 75 cm wide mafic dikes, now garnet amphibolite, which were metamorphosed and deformed with the anorthositic rocks. Locally, near the top of this unit, are elongate inclusions of white-green weathering, fine-grained epidote-garnet-plagioclase rock (unit 8e) and dark green weathering amphibolite which may represent recrystallized anorthosite fragments and fragments of country rock. The lower series is re-exposed in the core of the body due to re-folding.

The lower series is overlain by the main series, a sequence of melanoamphibolite (*gabbronorite*), thinly layered melanoamphibolite (*gabbronorite*) and norite (*leuconorite*), that has a maximum thickness of 250 m. The relationship of the norite to the melanoamphibolite is unclear. The norite appears as both metre-scale pods and layers in the melanoamphibolite. The norite may simply represent areas that are more resistant to metamorphic recrystallization and may have no stratigraphic significance. This is suggested by the fact that primary orthopyroxene in the norite is armoured by pale amphibole, biotite, and garnet, and that a progression from almost completely preserved orthopyroxene (thinly armoured) to almost completely recrystallized (thick armour) is present. This is consistent with the observations of Easton and Hrominchuk (1999) who noted that orthopyroxene-bearing units of the River Valley intrusion were more resistant to metamorphic recrystallization than were other units.

Discontinuous hornblendite and orthopyroxene hornblendite (*olivine orthopyroxenite* and *olivine websterite*) layers and pods on the order of 100 to 150 m long and up to 15 m wide occur sporadically at the contact between the lower and main series. These pods contain 30 to 40% poikioblastic orthopyroxene. Orthopyroxene poikioblasts are smaller (<2 cm diameter) and subrounded in these pods with respect to the larger (>2 cm) more euhedral, poikioblasts typical of the orthopyroxene hornblendites elsewhere in Street Township. Large erratics of orthopyroxene hornblendite occur along the western contact of the body, and may represent part of a small hornblendite body emplaced at the contact of the metagabbro and the host gneisses.

Figure 23 also compares the stratigraphy of the Street metagabbro with that of the East Bull Lake and Agnew Lake (Shakespeare–Dunlop) intrusions. The sequences are grossly similar with the Street metagabbro being most similar to the Agnew Lake intrusion particularly in terms of location of the inclusion-bearing zone and the fact that the gabbronorite overlying the gabbroic anorthosite zone is poorly layered. The most significant difference is that the Street metagabbro lacks part of the main series and all of the upper series present in both the East Bull Lake and Agnew Lake intrusions. Thickness differences between the lower and main series between the three intrusions (*see* Figure 23) may, in part, reflect tectonic thinning in the Street metagabbro.

GEOCHEMISTRY

The mafic intrusions of the East Bull Lake intrusive suite possess the following key chemical characteristics, namely, low S tenor, low TiO_2 (<0.6 wt. %), moderate to high Al_2O_3 (16 to 25 wt. %) contents, moderate Mg numbers, high background PGE (35 to 40 ppb), and show light rare earth element enrichment with no or slightly positive Eu anomalies (Easton and Hrominchuk 1999; James et al. 2002). The Street metagabbro shows all these characteristics, as illustrated in Figures 8, 15, 24 and 25, and as shown in the chemical analyses for units 7 and 8 listed in Appendix 1.

FELSIC INTRUSIVE ROCKS

Foliated to gneissic monzogranite to granodiorite (unit 9) occurs throughout the Grenville Province within Street Township, and in the Timmins Creek area. These rocks also occur on both sides of the Grenville Front boundary fault. Davidson (1998) has reported similar rocks from the Grenville Front tectonic zone to the southwest. Rocks of unit 9 were dated in two localities, north and south of the Grenville Front boundary fault of Lumbers (1973), giving ages of 2460±20 Ma and $2475^{+25}/_{-10}$ Ma, respectively (*see* Table 6; Corfu and Easton 2000). These ages are identical within error limits and are consistent with field evidence of incorporation of anorthositic blocks of the East Bull Lake intrusive suite (circa 2475 Ma) in rocks of unit 9 (Photo 8). The samples also indicate that a metamorphic or resetting event occurred at roughly 1720 Ma, in addition to Grenvillian metamorphism at approximately 990 Ma (*see* Table 6; Corfu and Easton 2000).

In the Timmins Creek area, south of the Ess Creek fault but north of the Grenville Front boundary fault of Lumbers (1973), is a fine- to medium-grained, foliated, monzogranite (unit 9a) surrounded by metasedimentary rocks of the Pecors and Mississagi formations all metamorphosed to amphibolite facies. This foliated granite is located approximately 500 m southwest of the exposures of felsic metavolcanic rocks of the Stobie Formation (unit 11). Contacts with adjacent units are not normally exposed, but at station 96RME-3163 (south side of the Grenville Front boundary fault), there is an exposure of a folded contact between granite gneiss and garnet-biotite gneiss (unit 12c).

The unit is foliated on the north side of the Grenville Front boundary fault, but consists of banded migmatitic gneissic granite south of the boundary fault. The foliated monzogranite to granodiorite (unit 9a) is homogeneous and does not contain migmatitic material or pegmatite. The monzogranite to granodiorite gneiss (unit 9b) is fine- to medium-grained, pinkish-grey and weathers pink. A millimetre- to centimetre-thick compositional layering is observed in many outcrops. In hand specimens, feldspar constitutes 35 to 50% and quartz as much as 45% of the rock. Dark coloured minerals are biotite and hornblende, and in a few places, dodecahedral crystals of garnet up to 0.7 cm in diameter. Leucosome and 2 generations of pegmatite dikes are commonly found in the granitic gneisses south of the Grenville Front boundary fault (Photos 9, 10). The leucosome and older generation of pegmatites strike parallel to regional foliation whereas the second generation of pegmatite (unit 25) transects the foliation (Photo 9, 10).

In thin section, the major mineral phases in unit 9a are plagioclase, potassium feldspar, quartz, biotite, calcium amphibole and secondary chlorite with accessory titanite, rutile, epidote, apatite and opaque minerals. Brown-black laths of biotite define the foliation fabric. Sub- to idioblastic garnets in metagranites have poikioblastic cores and inclusion free rims that are indicative of syn- to posttectonic garnet growth. The equilibrium assemblage is hastingsitic hornblende-plagioclase (An_{12-22})-biotite-muscovite-garnet-potassium feldspar-quartz (Murphy 1999, 2001). Coloured mica is magnesium-rich and plots in the phlogopite field on mica classification diagrams (Murphy 1999, 2001). Calcium amphiboles lie in the same compositional domain as those from units 10 and 18, suggesting that unit 9a experienced similar metamorphic conditions (i.e., amphibolite facies) (Murphy 1999, 2001).

In thin section, the monzogranite to granodiorite gneiss (unit 9b) contains plagioclase (An_{15-18}), hornblende and biotite with a similar paragenesis to those minerals in unit 9a (Murphy 1999, 2001). The main differences between units 9a and 9b are grain size and texture (gneissic in unit 9b). Biotite from units 9a and 9b plot in the same group on mica classification diagrams, and the anorthite component in plagioclase is almost identical between the two units (Murphy 1999, 2001). Amphibole compositions also overlap one another and correspond to hastingsitic hornblende (Murphy 1999, 2001).

Retrograde metamorphism and the development of mylonitic textures (unit 9c) occur within rocks of unit 9 adjacent to the Grenville Front boundary fault where large amounts of chlorite and hematite are present. These minerals suggest greenschist metamorphic conditions along this fault.

Similar granitoid rocks (unit 9b) occur south of the Grenville Front boundary fault, however, they contain a granitic leucosome phase not observed to the north. The granitoid bodies commonly occur in the cores of regional antiforms related to F_2 folding in the region and are generally surrounded by garnet-biotite migmatitic gneisses. The presence of these rocks in the core of folds, as well as their migmatitic character, suggest that they may have been basement to the surrounding garnet-biotite migmatitic gneisses. Geochronology indicates, however, that these plutonic rocks are early Paleoproterozoic in age (*see* Table 6) and are likely younger than the host migmatitic gneisses.

Units 9a and 9b are similar in chemistry and age (Corfu and Easton 1998, 2000; Easton 1999a) and are chemically similar to felsic metavolcanic rocks of the Stobie Formation within and outside of the map area (Easton 1999a). Consequently, in the Timmins Creek area, rocks of unit 9a and 9b are interpreted as part of the same intrusion and simply exhibit different textures that reflect increasing deformation and metamorphic conditions toward the Grenville Province.

Geochemistry

Geochemical data are available from 10 granitoid gneisses (unit 9) and 2 samples of felsic metavolcanic rocks (unit 11) from Street Township (Appendix 1). In addition, Easton and Hrominchuk (1999) have reported geochemically and lithologically similar felsic metavolcanic and granitoid rocks near the Grenville Front in Dana township to the east. The felsic metavolcanic rocks (unit 11) are similar to Stobie Formation dacites from the Sudbury area (e.g., sample 96RME-0124, Appendix 1) and with the Street Township granitoid gneisses. The granitoid gneisses have a limited compositional range in both major oxide and trace element chemistry (Appendix 1).

Both the felsic metavolcanic rocks and the granitoid gneisses are characterized by SiO_2 = 66 to 72 wt. %, Al_2O_3 = 11.9 to 12.6 wt. %, FeO^{total} greater than 3.5 wt. %, CaO greater than 1.5 wt. %, Eu/Eu* = 0.55 to 0.70, La/Yb = 5 to 8 and Gd/Yb = 1.2 to 1.65 and are identical in major and rare earth element geochemistry with Stobie Formation dacites from both the Sudbury and Street Township areas. These rocks plot in either the "Within-Plate" or "Rift-Related" granite fields on various geochemical discrimination diagrams. Other important chemical characteristics of both the dacites and the granitoid gneisses include Zr/Y ratios of 5 to 7.5, Zr = 280 to 790 ppm, Y = 42 to 110 ppm, TiO_2 = 0.3 to 0.8 wt. %, Sc = 6 to 12 ppm, Sr = 110 to 210 ppm and elevated, flat rare earth element patterns with negative Eu anomalies. All of these features are typical of FIIIb type rhyolites which are typically associated with Archean and younger volcanogenic massive sulphide (VMS) deposits (Lesher et al. 1986; Parker and Ayer 1997; Hart et al. 2001).

The geochemical signature of these rocks is illustrated in Figures 26 to 29. Figure 26, an AFM and a Jensen diagram, indicate that the Stobie Formation dacites and the Street Township granitoids are tholeiitic in character and form a distinct group. This is consistent with the data for the adjacent mafic metavolcanic rocks in Street Township which also compare closely with Stobie Formation rocks from the Sudbury area (*see* Figure 25). In contrast, data for the Copper Cliff rhyolites as well as the Murray and Creighton granites plot in the calc-alkalic field (*see* Figure 26). Two Copper Cliff rhyolite samples from the literature (*see* Appendix 2) plot in the Stobie field of the diagrams which may suggest that they represent Stobie Formation rocks incorrectly identified as the Copper Cliff Formation. Figure 27 shows 3 different granite classification plots that depict a generally tight cluster of the data from Stobie–Street felsic rocks and a wider scatter of the Copper Cliff–Creighton data. This wide dispersion in the Copper

Cliff data might reflect addition of alkalis, however, insufficient data exist to test this suggestion. The Stobie–Street felsic rocks consistently plot in the "Rift-Related Granite" or "Within-Plate Granite" fields which is consistent with the inferred tectonic setting for these rocks. Figures 28 and 29 show rare earth element patterns for the Stobie Formation felsic metavolcanic rocks and the Street Township granitoids, respectively, and illustrate the geochemical similarity of these two groups of felsic rocks.

In contrast to the Stobie-Street felsic rocks, felsic rocks of the Murray and Creighton granites and the Copper Cliff rhyolite have lower FeO^{total} contents and higher SiO_2 and alkali contents (Appendix 1; *see* Figure 26). In addition, rare earth element data (only available from a single Copper Cliff rhyolite sample (*see* sample 86RLD-5302, Appendix 1) have Eu/Eu* less than 0.5, La/Yb less than 5.5 and Gd/Yb less than 0.75 with low total REE abundances.

The Street Township granitoid gneisses are also chemically distinct from Neoarchean granitic rocks in the Sudbury area such as the Cartier batholith (Meldrum et al. 1997). For example, data from the Cartier batholith plot in the "Syn-collision Granite" field on a Pearce, Harris and Tindle (1984) diagram (not shown) plot and are peraluminous, whereas Street Township granitoids plot in the "Within-Plate Granite" field and are metaluminous.

HURONIAN SUPERGROUP (UNITS 10 TO 17)

Introduction

The stratigraphy of the Huronian Supergroup in the Sudbury area is outlined in Figure 2. Debicki (1990) provides a detailed review of the stratigraphy in the Sudbury, including petrographic descriptions of the various formations and measured stratigraphic sections. Rocks of the Huronian Supergroup in Street Township occur in both the Southern and Grenville provinces, although not all Huronian Supergroup formations have metamorphosed equivalents within the Grenville Province. Specifically, only the Stobie, Pecors and Mississagi formations have equivalents within the Grenville Province in Street Township. Rocks of the Elliot Lake Group as well as the Ramsay Lake and Lorrain Formations are apparently absent within the Southern Province in Street Township.

Huronian strata occur in 3 domains within Street Township (*see* Figure 6). In the first domain, east of the Wanapitei River, the Huronian Supergroup forms a continuous west-facing section through the Hough Lake and Quirke Lake groups. Here, the Bruce and Espanola formations are less than 350 m and 80 m thick, respectively. Maximum metamorphic grade is chlorite-biotite-muscovite, present only 200 m west of the Grenville Front near Jackson Lake. In the second domain, west of the Wanapitei River, the Huronian Supergroup consists of Serpent Formation quartz arenites locally capped by Gowganda Formation conglomerates. A Nipissing gabbro sill occurs locally along the basal Serpent contact in the southwest part of the map area. Previous maps (Dressler 1984a) show a syncline in the Gowganda Formation in this area with the section east of the river representing one limb, however, the results of this study suggest that the structure is actually an antiformal syncline. Alternatively, the Gowganda Formation may unconformably overly the Serpent Formation as described by Debicki (1990) in Scadding Township to the north. In the third domain, in north Street Township, Hough Lake and Quirke group strata are folded into broad, variably plunging, east-trending, synclines and anticlines of indeterminate form (Map P.3427, back pocket). Here, the Bruce and Espanola formations are greater than 500 m and 200 m thick, respectively. Nipissing gabbro does not intrude this section, but does cut Cobalt Group strata to the north. Metamorphic biotite has not been found north of the Ess Creek fault, even in Huronian Supergroup rocks within 150 m of the Grenville Front. Figure 5 illustrates the variations in thickness of the various Huronian Supergroup formations from west to east across Street Township.

Geochemistry

The use of rare earth elements as indicators of provenance in sedimentary and metasedimentary rocks, particularly in pelitic and semipelitic rocks, is well documented by Taylor and McClennan (1985) and Easton (1982). The Huronian Supergroup has been the focus of several such provenance studies due to its location at the Archean–Proterozoic transition (e.g., McLennan, Fryer and Young 1979; Fedo et al. 1997; Fedo, Young and Nesbitt 1997), consequently, a considerable amount of rare earth element data exist for the more pelitic members of the Huronian Supergroup. Easton and James (1997b) suggested that this database be used for metamorphosed schists and paragneisses within the Grenville Province to distinguish between Huronian and non-Huronian strata, particularly within the Timmins Creek area, where the majority of possible metamorphosed Huronian Supergroup rocks are located. Murphy (1999) validated this approach and it was used in the designation of map units for metasedimentary rocks within the Grenville Province shown on Map P.3427 (back pocket). The majority of these rocks occur in the Timmins Creek area, consequently, it is best to summarize the geochemical features of Huronian Supergroup rocks in Street Township prior to describing the respective stratigraphic units found within the map area.

Pelitic rocks world-wide generally fall into 2 clearly defined groups, one exhibiting patterns similar to the average Archean Australian shale (AAS) composite and the other being similar to post-Archean shale composites such as PAAS, NASC, and ES (post-Archean Australian sedimentary rock, North American shale composite and European shale composite, respectively) (Taylor and McClennan 1985 and references therein). Pelitic rocks with rare earth element patterns similar to AAS can occur in non-Archean successions, but generally only in arc environments characterized by rapidly deposited, volcanic-dominated, sedimentation.

Figure 30a illustrates the variation in rare earth element patterns for the Huronian Supergroup stratigraphy in the Sudbury area utilizing data from representative samples that were collected during this study or re-analyzed samples from Debicki (1990). For comparison, Figure 30b illustrates the variation in rare earth element patterns for potential Huronian Supergroup rocks from the Grenville Province in Street Township. The rocks in Street Township fall into 2 groups, one characterized by low total rare earth element abundances and no Eu anomaly; the other characterized by higher total rare earth element contents and a slightly negative Eu anomaly. All of the Street Township samples shown in Figure 30b are non-conglomeratic thereby eliminating the Bruce Formation as a possible source rock. In comparing Figures 30a and 30b, it is apparent that the rare earth element patterns shown by samples 96RME-0122 and 96RME-3040 are equivalents to the Mississagi Formation (sample 96RME-0092 is a Mississagi Formation sample located immediately north of the Grenville Front). Samples 96RME-0183, 96RME-0184, 96RME-0234 and 96RME-0242 could be derived from either the Pecors or the McKim formations based on REE signature. Comparison of REE chemistry with major element data, such as iron, effectively eliminates the McKim Formation as a source for the rocks shown in Figure 30b.

Major element chemistry (Figures 31a and 31b) further divides the pelitic rocks and paragneisses into two main groups. One group overlaps the field of known Mississagi Formation samples (*see* Figures 31a and 31b) whereas the second group has no clear affinity. The field of Mississagi Formation includes samples collected from north of the Grenville Front in Street Township, as well as white-mica schist (unit 13d, samples 96RME-0122, 96RME-3040, Appendix 1) intruded by Nipissing gabbro located immediately south of the Ess Creek fault. Two samples from the Mississagi Formation group of samples have unusual rare earth element patterns (96RME-3030, 96RME-3031, Appendix 1) (Figure 32). Both samples have a sharp positive Eu anomaly ($Eu/Eu^* = 2.01$), steep LREE depletion and slight HREE enrichment. Similar patterns have been recognized by C. Fedo (Geochemist, personal communication, 1998) from some units within the Mississagi Formation in the Sudbury area where the pattern is present

in a Mississagi Formation sample collected by Debicki (1990) (sample 86RLD-3902, Appendix 1). To date, these unusual REE patterns have only been found in rocks of the Mississagi Formation and there presence is consistent with other data indicating that the Timmins Creek metasedimentary rocks assigned to unit 13 are most likely equivalents of the Mississagi Formation. Murphy (1999, 2001) interpreted these unusual samples as reflecting significant input from high-grade Archean gneisses located northwest of the study area (e.g., the Levack gneisses located on the north side of the Sudbury Structure). Although certainly possible, another more plausible explanation is a source region to the east-northeast. Evidence in favour of this second possibility is provided by Easton (2000) who reported the presence of Archean, fertile, S-type, granite cumulate rocks, in the River Valley area, that are characterized by sharp positive Eu anomalies (Eu/Eu* = 2.01), steep LREE depletion and slight HREE enrichment. A Mississagi Formation sample from the River Valley area located near these granites is characterized by a positive Eu anomaly and a REE pattern similar to those reported from the Timmins Creek area (*see* Figure 32). A source region to the east-northeast would be consistent with regional paleocurrent data (Debicki 1990).

Rare earth element patterns can be used to further distinguish samples within the second major element group. As noted by McClennan et al. (1979), the magnitude of the negative Eu anomaly increases from the base to the top of Huronian stratigraphy. Consequently, the value of the Eu anomaly can be used to identify specific Huronian Formations among the Timmins Creek metasedimentary rocks. For example, kyanite-staurolite-bearing schists and gneisses (samples 96RME-0242, 96RME-0234) on both sides of the Grenville Front boundary fault have nearly identical rare earth element patterns (Figure 30b), exhibiting a moderate slope (La/Yb = 16±2) and a weak negative Eu anomaly (Eu/Eu* = 0.87). The total rare earth element content and the Eu/Eu* ratio indicates that these rocks may be correlated with McKim (Eu/Eu* = 0.86±0.02) or the Pecors (Eu/Eu* = 0.85±0.08) formations of the Huronian Supergroup, however, major element chemistry (e.g., iron content) essentially eliminates the McKim Formation. On the binary diagrams (*see* Figure 31a and 31b), most pelitic schist and paragneiss samples from the Timmins Creek area plot in the Pecors field and exhibit REE patterns similar to those reported from Pecors Formation samples (*see* Figure 30b).

The rare earth elements can also be used to exclude paragneiss samples from the Huronian Supergroup as illustrated in Figure 33. Here, 2 samples of biotite-garnet-muscovite schist (samples 96RME-3023 and 96RME-3028) have steeply sloping rare earth element patterns with moderate light rare earth enrichment. These patterns are typical of the average Archean Australian Shale composite (AAS) or FI type rhyolites and effectively exclude these samples from the Huronian Supergroup. Accordingly, these two samples were assigned to the felsic gneisses (unit 3) on Map P.3427 (back pocket).

Elliot Lake Group

STOBIE FORMATION (UNITS 10, 11)

Horizons of mafic and felsic metavolcanic rocks (units 10 and 11) that occur in the Timmins creek area, south of the Ess Creek fault, were first mapped by Lumbers (1973). Lumber (1973) included them within the Mississagi Formation: an assignment consistent with their regional stratigraphic position and the absence of intervening members of the Elliot Lake (Matinenda and McKim formations) and Hough Lake (Ramsay Lake Formation) groups in the area south of Wanapitei Lake. Easton et al. (1996) and Murphy (1999, 2001) have correlated these metavolcanic rocks with the Stobie Formation on the basis of lithological similarities, stratigraphic position and whole-rock geochemistry (*see* "Huronian Supergroup Geochemistry"). To the south, the metavolcanic units are overlain by metamorphosed polymictic conglomerate that Murphy (1999, 2001) has correlated with the Ramsey Lake Formation, although it is also possible that this metaconglomerate is part of the Stobie Formation. Garnet-biotite schists overlying the conglomerate are tentatively correlated with the Pecors Formation of the Hough Lake Group. All

exposures of rocks of unit 10 and 11 lie in the Grenville Province within Street Township, albeit between the Ess Creek fault and the Grenville Front boundary fault.

Mafic Metavolcanic Rocks (Unit 10)

This unit (10) consists of a 60 to 120 m wide (apparent thickness) horizon of foliated, fine- to medium-grained, well-banded amphibolite schist (unit 10a); foliated, medium-grained amphibolite (unit 10b); and garnet amphibolite (unit 10c). Foliation in all units strikes 050° to 060°, dipping 75° southeast. The mafic metavolcanic rocks extend to the east of the map area. West of Timmins Creek the mafic metavolcanic rocks are cut off by a northeast-trending fault documented in diamond-drill core (Craigie 1976), however, the rocks reappear further to the west and northeast of Jackson Lake. Weathered surfaces of the amphibolite schist unit (unit 10a) exhibit banding that is due to alternating distinct, dark mafic (amphibole + chlorite, epidote) and leucocratic (quartz, plagioclase, epidote) layers. Small-scale asymmetric S and Z isoclinal drag folds are present in the banded rocks. The amphibolite schist units also appear to be flattened (tight isoclinal folds) and some parts of the outcrop could be described as blastomylonitic. In thin section, the amphibolite schists consist of amphibole (70 to 80%) and plagioclase (15 to 20%) with minor quartz and chlorite and lesser epidote, biotite, muscovite, titanite, iron-titanium oxides and sulfide minerals. Quartz veins, with minor carbonate and garnet locally, range in thickness 1 to 7 mm and composes 2% of the schist. These veins are oriented parallel to the plane of foliation and are also affected by the S-type folding where they have been boudinaged. The nematoblastic texture (i.e., aligned, elongate crystals) of these rocks shows a strong lineation defined by ferrotschermakitic hornblende (Murphy 1999, 2001) that lies within the S_1 fabric. Narrow felsic veinlets of carbonate, quartz and garnet are 2 to 4 mm in width and parallel to the S_1 foliation. The equilibrium mineral assemblage of ferrotschermakitic hornblende-plagioclase (An_{15-20})-biotite-titanite-ilmenite-epidote indicates that these rocks underwent lower amphibolite facies metamorphism (Murphy 1999, 2001).

A garnet amphibolite dike (unit 10d) transects rocks of unit 12a, but is included within this unit because the dike rock is not chemically similar to mafic intrusive rocks of either the East Bull Lake or Nipissing intrusive suites or the Sudbury dike swarm. Chemically, it is most similar to some amphibolite units (unit 10b) within the Stobie Formation, hence its inclusion within this formation (compare samples 96RME-0233 and 96RME-0123, Appendix 1). The dike consists of medium-grained, garnet-bearing amphibolite with dark grey-black weathered and fresh surfaces. The rock is homogeneous with the parallel alignment of amphibole needles defining a northeast-trending lineation. Garnet comprises about 3 to 5% of the rock and forms 50 to 100 mm size porphyroblasts that exhibit cross-like shapes. There are no pressure shadows around garnet porphyroblasts which indicates that the garnets are posttectonic with respect to the foliation. In thin section, the rock is composed of calcium amphibole, plagioclase, garnet, quartz and biotite with accessory epidote, titanite and opaque minerals. Garnet occurs as xenoblastic to sub-idioblastic grains, which are highly poikioblastic and contain inclusions of quartz, plagioclase, opaque minerals, biotite and secondary chlorite. The garnet-hornblende-biotite-plagioclase assemblage is in textural equilibrium and corresponds to conditions of middle amphibolite facies metamorphism (Bucher and Frey 1994; Murphy 1999).

Geochemical data on samples of unit 10 are listed in Appendix 1. Figures 8a, 8b and 19 indicate that mafic metavolcanic rocks from the study area plot in the same field as other Huronian mafic metavolcanic rocks from the Sudbury area (i.e., Stobie and Elsie Mountain formations). Rare earth element data are only available for a single Stobie Formation metavolcanic rock from the Sudbury area, but its pattern is similar to that observed from the Timmins Creek metavolcanic rocks (*see* Figure 19). The geochemical data are consistent with Lumbers (1973) assignment of the mafic metavolcanic rocks (unit 10) in the Timmins Creek area to the base of the Mississagi Formation. This is supported by the presence of neighbouring felsic metavolcanic rocks (unit 11), which are geochemically similar to Stobie Formation felsic metavolcanic rocks.

Felsic Metavolcanic Rocks and Related Metasedimentary Rocks (Unit 11)

A small lens-shaped body of metamorphosed felsic pyroclastic rock (unit 11a), about 30 m wide (apparent thickness), is located in the northeast part of Street Township. This felsic unit occurs structurally (and stratigraphically?) above the mafic metavolcanic rocks. The felsic unit is conformably underlain by semipelitic metasedimentary rocks (unit 11b) of unknown total thickness but likely less than 25 m thick. The metasedimentary rocks (unit 11b) contain 60 to 100 cm thick massive quartz-rich sandstone layers and 10 to 20 cm thick, mica-rich, schistose mudstone layers. The quartz-rich metasandstones (unit 11b) are resistant to weathering and graded bedding is preserved locally indicating that the metasedimentary rocks are southward-facing (Murphy 1999, 2001).

The matrix of the felsic pyroclastic unit (unit 11a) is foliated, greenish grey (fresh surface) or grey to tan (weathered surface), fine- to medium-grained quartz, feldspar and amphibole with lesser biotite. Lens-shaped "fragments" within unit 11a, composed mostly of quartz and feldspar with 1 to 2% mafic minerals, are common and elongated in the plane of the foliation (060°). The clasts are interpreted to represent thoroughly welded, recrystallized pumice shards or volcanic bombs. Although some of the "fragments" may be boudinaged layers or veins, the abundance of these fragments and their distribution suggests that many of them do indeed represent fragments. In thin section, unit 11a exhibits lepidoblastic textures and distinct alignment of sub-idioblastic hastingsitic hornblende (Murphy 1999, 2001), plagioclase (An_{20-22}) and brown pleochroic biotite along the foliation. The geochemistry of unit 11a rocks was described in a previous section on "Felsic Intrusive Rocks, Geochemistry" in conjunction with the description of the geochemistry of granitoid rocks of unit 9. Analytical data are given in Appendix 1 and are illustrated in Figures 26 to 29.

In the Timmins Creek area, a schistose polymictic conglomeratic (units 11c, 11b) overlies the amphibolite schist. The contact between the metasedimentary and the mafic metavolcanic rocks is not exposed. Unit 11c is approximately 75 m wide (apparent width) and consists of metaconglomerate with a minor amount of interlayered schistose meta-arenite (unit 11b). The contact between meta-arenite (unit 11b) and metaconglomerate (unit 11c) strikes 050°. The meta-arenite is white-grey and medium grained. There are abundant boudinaged quartz veins within both the meta-arenite and the metaconglomerate. These veins are folded with a similar fold pattern to the veins observed in the mafic metavolcanic rocks (unit 10).

Grain size in the metaconglomerate (unit 11c) is varied: the average size of pebbles in the conglomerate is 0.5 to 1 cm wide by 3 to 5 cm long. These highly flattened pebbles are aligned along the foliation (060°). The pebbles include quartzite, granite and possible metasedimentary or metavolcanic rocks. The matrix varies in composition from a quartz-feldspar-mica-rich composition to more mafic, amphibole-rich compositions. The grain size of the matrix is varied and ranges from medium- to coarse-grained. Syntectonic to posttectonic almandine garnet is present throughout the matrix and varies in size from 50 to 80 mm. The garnets are not clasts and are not flattened, but do exhibit pressure shadows. Amphibole within the metaconglomerate is ferrotschermakitic hornblende (Murphy 1999). Murphy (1999, 2001) concluded that since similar hornblende compositions occur in unit 10 that some of the clasts in unit 11c were derived from unit 10.

Murphy (1999, 2001) correlated unit 11c with the Ramsay Lake Formation mainly on apparent stratigraphic position. In this report, the unit is considered part of the Stobie Formation in part because; 1) meta-arenite is present between metavolcanic rocks of units 10 and 11 and similar meta-arenite immediately underlies the metaconglomerate, and 2) lithologically, the conglomerate is not typical of the Ramsay Lake Formation in either clast population or matrix characteristics.

Hough Lake Group

PECORS FORMATION (UNIT 12)

The Pecors Formation consists of grey to tan to buff siltstone, wacke and arenite (Debicki 1990). Debicki (1990) reported a maximum thickness of 280 m with the formation being absent in Falconbridge Township but being up to 60 m thick in areas south of Wanapitei Lake. The formation is not exposed in Street Township in the Southern Province, although it is possible that rocks of the Pecors Formation may underlie a large swamp immediately east of the Kukagami Lake road, north of the abandoned rail line, in the core of an F_2 antiform.

Within the Timmins Creek area, in the Grenville Province, much of the garnet-biotite schist present between the Ess Creek fault and the Grenville Front boundary fault may be correlative with the Pecors Formation based mainly on geochemical and lithological characteristics (*see* "Huronian Supergroup Geochemistry"). If this correlation were correct, then the Pecors Formation would overlie the metavolcanic rocks of the Stobie Formation. The thickness of the formation in this area would be about 60 to 75 m thick taking into account the considerable fold repetition in this area.

Murphy (1999, 2001) recognized two subdivisions within garnet-biotite schists—garnet-biotite schist (unit 12a) and staurolite-kyanite-garnet-muscovite schist (unit 12b)—and interpreted them to be correlative with the Pecors Formation in the Timmins Creek area between the Ess Creek fault and the Grenville Front boundary fault. Gneissic equivalents of these two units occur south of the Grenville Front boundary fault, namely garnet-biotite gneiss (unit 12c) and garnet-kyanite-muscovite gneiss (unit 12d).

Garnet-biotite schist (unit 12a) lies south of the metaconglomerate (unit 11c) and is in sharp contact with it. The garnet-biotite schist unit is 50 to 60 m wide (apparent width), medium-grained, brownish-grey on weathered surfaces and bimodal in composition. Fine- to medium-grained, sandy layers from 2 to 70 cm thick are predominant (approximately 80%). The remaining 20% are composed of 1 to 3 cm wide, medium-grained, mica-rich layers. As a result, the unit has a banded appearance in outcrop probably reflecting transposed bedding (Photo 11). Relict graded bedding was observed within the sandy portion of this garnet-biotite schist but it was difficult to reliably identify facing direction. Layering (i.e., transposed bedding) is at a high angle to the S_1 foliation in the nose of folds but typically subparallel or parallel to foliation on the limbs of folds (Murphy 1999, 2001). Quartz-rich layers (possibly veins) display a similar fold pattern to the veins observed in both the mafic metavolcanic and metaconglomerate units. In thin section, the matrix of the garnet-biotite schist is medium- to coarse-grained, foliated and micaceous. The main rock-forming minerals are quartz, plagioclase, muscovite, biotite, garnet, staurolite and trace kyanite. Accessory amounts of ilmenite, titanite and rutile are present. Secondary epidote is usually present after plagioclase, whereas chlorite mostly occurs as a retrograde phase after garnet and biotite (Murphy 1999, 2001).

Both biotite and muscovite laths define the S_1 foliation plane in the schists of unit 12a and 12b. Murphy (1999) provides mineral chemistry on biotite from these units, with Fe/(Fe+Mg) for biotite ranging between 0.47 to 0.77. Garnet forms idioblastic porphyroblasts most of which exhibit poikioblastic textures. Some garnet porphyroblasts have cores with abundant fine-grained inclusions of plagioclase, quartz and opaque minerals and relatively inclusion free rims. Other garnets are slightly elongate parallel to the S_1 foliation. These characteristics of the garnets and their well-defined crystal boundaries indicate syntectonic to posttectonic growth of garnet. Almandine garnets show the compositional range $Al_{69-76}Gr_{4-16}Sp_{1-9}Py_{4-16}$ (Murphy 1999). Microprobe traverses across individual garnets from different layers in the metasedimentary rocks show some compositional variation, but most garnet grains are uniform with cores slightly enriched in magnesium and depleted in iron(Murphy 1999). A very few garnet grains show a pronounced bell-shape distribution for MnO (Murphy 1999) which

probably records the progression of metamorphic conditions from greenschist- to amphibolite-facies during garnet growth (F. Ford, petrologist, personal communication, 1997, 1998). The compositionally homogeneous garnets that are the most common in these rocks indicate sustained growth under relatively constant temperature conditions (Spear 1993).

Staurolite-kyanite-garnet-muscovite schist (unit 12b) lies south of the garnet-biotite schist unit and is interpreted to overlie it, however, the contact between unit 12a and 12b is not exposed. It is structurally overlain by the Grenville Front boundary fault. Features such as bedding, similarities in metamorphic grade and fold pattern indicate that both units were deposited, deformed and metamorphosed at the same time (*see* Table 6) and in a similar environment. Unit 12b consists of 10 to 70 cm thick layers of sandy semipelite and 1 to 3 cm thick layers of pelite. The colour of the weathered surface is light brownish-grey and the fresh surface is light greenish-grey. Coarse-grained muscovite-rich beds correspond to original mudstone layers with medium-grained quartz-feldspar-rich layers representing original sandstone. The fold pattern of this unit is similar to that in the garnet-biotite schist. Tight east-northeast-trending folds occur on an outcrop scale. In several locations, an angular relationship between primary bedding (S_0) and axial planar foliation (S_1) was observed (Murphy 1999, 2001). In thin section, the main rock forming minerals are quartz, feldspar and white mica, 3 to 5% garnet, staurolite, kyanite and minor biotite. Staurolite forms xenoblastic crystals that have sharp mineral boundaries with the muscovite-biotite-garnet assemblage. Kyanite occurs as individual sub-idioblastic blades that are oriented parallel to the S_1 foliation (Murphy 1999, 2001). The assemblage kyanite-staurolite-garnet-biotite-muscovite-quartz-plagioclase is in textural equilibrium in these rocks and forms a syn- to post-early folding fabric. Collectively, the mineralogy present in units 12a and 12b indicate that these units attained the staurolite-kyanite subfacies of the amphibolite facies zone (Bucher and Frey 1994; Murphy 1999, 2001).

The migmatitic, garnet-biotite gneiss unit (unit 12c) lies immediately south of the Grenville Front boundary fault. These rocks are well foliated, gneissic and locally schistose. The rocks are also brownish-grey to dark-grey and fine- to medium-grained. Compositional layering, that may represent transposed bedding, is common. The main mineral phases are quartz, plagioclase, biotite, hornblende and garnet. Garnet is common, but its quantity varies considerably, even on an outcrop scale. Locally, garnet may constitute more than 40% of the rock. The garnet is brownish red and commonly 1 to 7 mm in diameter but may exceed 2.5 cm. Garnet shows both syntectonic pressure shadows and posttectonic characteristics (Murphy 1999, 2001). The leucosome in unit 12c consists of quartz and feldspar and forms discontinuous, boudinaged thin layers that are elongated in the foliation plane and up to 10 cm wide and twice as long. Locally, the leucosome contains 5 to 7 cm diameter porphyroblasts of feldspar aligned along the foliation. Commonly the leucosome appears to be restricted to specific layers within the gneiss.

There are discontinuous lenses of fine- to medium-grained foliated garnet-amphibolite layers 0.5 to 2 m wide within the garnet-biotite gneiss. The amphibolite layers are conformable to the foliation plane and layering in the gneisses and may be thin dikes that are equivalent in age to the Nipissing sills that occur in the schistose rocks north of the Grenville Front boundary fault (Murphy 1999, 2001). The dikes may also be related to the garnet-amphibolite dikes of unknown affinity (unit 11d) that also cut the schist.

The garnet-biotite gneiss unit (unit 12c) is cut by two generations of granitic pegmatite veins. One generation is commonly boudinaged, locally protomylonitic and parallel to leucosome layers. This generation of pegmatite may be similar in age and origin to the leucosome. The other generation of pegmatite veins is younger (unit 25) and cuts layering in the gneisses at a high angle.

The garnet-kyanite-muscovite gneiss unit (unit 12d, Photo 12) occurs in a lens up to 30 m wide and 250 m long on the south side of the Grenville Front boundary fault at the contact between garnet-biotite and garnet-amphibolite gneiss. These rocks are brownish-grey on the weathered surface and light grey on the fresh surface. The major constituents of unit 12d are quartz, feldspar and muscovite with lesser

biotite, garnet, kyanite and staurolite. Staurolite is only visible in thin section. The gneiss is generally medium-grained with garnet porphyroblasts 2 to 5 mm in diameter and kyanite blades from 3 to 4 mm wide and 5 to 7 mm in length. Compositional layering is not apparent within the garnet-kyanite-muscovite gneiss. Leucosome is present, but not abundant (<10%), and there are a few boudinaged quartz veins parallel to the gneissosity (060°) in this unit.

Both the garnet-biotite and garnet-kyanite-muscovite gneiss (units 12c and 12d) display similar textures in thin section. All exhibit lepidoblastic textures in a coarse-grained matrix that hosts poikilitic garnet porphyroblasts. Biotite and muscovite define a folded S_1 fabric. Mineral compositions of biotite in these rocks are similar to those reported from the schist units (units 12a and 12b) (Murphy 1999). The significant differences between units 12a-12b and 12c-12d are 1) the modal proportions of some mineral phases; 2) grain size; and 3) the presence of granitic leucosome in the gneiss.

The garnet-kyanite-muscovite gneiss (unit 12d) shows near similar modal mineralogy to the staurolite-kyanite-garnet-muscovite schist (unit 12b). Chemical analyses of plagioclase, biotite and garnet from these two rocks are identical (Murphy 1999, 2001). This similarity in mineral chemistry of the major phases suggested to Murphy (1999, 2001) that these rocks had the same protolith and underwent a similar metamorphic history. Whole rock geochemistry also establishes that these two units (unit 12b and 12d) have the same composition. There is a difference, between the schist and gneiss units, in the modal abundance and textures of kyanite and staurolite (units 12b and 12d). In the gneiss (unit 12d) kyanite is abundant whereas staurolite occurs in trace amounts, and sub- to idioblastic blades of kyanite are oriented parallel to the folded S_1 foliation. In the gneiss, staurolite occurs as small, scarce, xenoblastic inclusions dispersed within the garnet porphyroblasts and kyanite blades and as elongate and apparently very scarce crystals in the S_1 foliation plane (Murphy 1999). In contrast, kyanite is rare in the schist unit (unit 12b), with staurolite occurring as large inclusion-rich porphyroblasts. The increasing abundance in kyanite with increasing distance into the Grenville Province suggests that the continuous reaction staurolite + biotite = kyanite + garnet had neared completion in favour of the mineral phases in the gneiss unit. This indicates that the gneiss reached middle- to upper amphibolite facies conditions (Bucher and Frey 1994; Murphy 1999, 2001).

MISSISSAGI FORMATION (UNIT 13)

The Mississagi Formation (unit 13) (Winchell 1888) occurs in both the Southern Province and in the Timmins Creek area of the Grenville Province in Street Township. Dressler (1982) estimated the thickness of the formation at 1050 m in the Wanapitei Lake area, and Debicki (1990) reported a thickness of 3080 m in south Falconbridge Township. Debicki (1990) reported a minimum thickness of 450 m in a measured section in Street Township. As noted by Debicki (1990) the Mississagi Formation is disconformable with the underlying units of the Elliot Lake and lower Hough Lake groups. For example, in Falconbridge Township, the Mississagi Formation directly overlies the Ramsey Lake Formation, the Pecors Formation and the Stobie Formation. Within the Lake Wanapitei area, the Mississagi Formation rests directly on Archean basement (Dressler 1982). Within the Southern Province in Street Township, the base of the Mississagi Formation is not directly observed in the central and southwest parts of the township. The Mississagi Formation may overlie rocks of the Pecors Formation, west of the Kukagami Lake road in the north part of the township, but the Pecors Formation is not exposed in surface outcrops. In the Grenville Province, in the Timmins Creek area, the Mississagi Formation may rest directly on Stobie Formation metavolcanic rocks or on metapelite of the Pecors Formation.

The Mississagi Formation in the Southern Province consists of tan to grey arenite that weathers tan to buff to pinkish, with minor amounts of reddish-brown weathering wacke and siltstone. The formation consists mainly of thickly bedded, cross-stratified, medium- to coarse-grained arenite to wacke with minor amounts of interstratified, massive to parallel-laminated siltstone and fine-grained wacke. The

siltstone and fine-grained wacke interbeds are most common in the lower 250 m and in the uppermost 500 m of the formation. The siltstone and fine-grained wacke interbeds are generally less than 10 cm thick although they be as much as 20 cm thick. In many locations, the siltstone and fine-grained wacke fill shallow channels in the underlying beds. The medium- to coarse-grained arenite occurs in beds that are 10 to 150 cm thick. Most beds are tabular and thickest in the middle part of the formation (Debicki 1990). Planar cross-beds, trough cross-beds and cosets of the two are present in the lower 250 m of the Mississagi Formation but are most common in the middle part of the formation (Debicki 1990).

Arenite samples contain 45 to 75% quartz, 1 to 25% potassium feldspar, 1 to 10% plagioclase and 1 to 10% white mica. Wacke samples contain 35 to 50% quartz, 0 to 10% potassium feldspar, trace amounts of plagioclase and 35 to 60% matrix consisting of a mixture of white mica, detrital biotite, chlorite after biotite and fine-grained quartz and feldspar.

Immediately north of the Ess Creek fault, rocks of Mississagi Formation consist of tan to grey, medium- to coarse-grained arenite that weathers tan to buff, grey and rusty, with minor amounts of fine- to medium-grained metawacke and metasiltstone. Coarse-grained varieties of meta-arenite contain pebbles that are elongated parallel to the foliation (027° to 030°). Pebble size in the meta-arenite is 0.5 to 1 cm along the short axis and 1 to 2 cm in length.

Rocks of the Mississagi Formation become increasing deformed proximal to the trace of the Ess Creek fault on its north side. Drag folds have axial planes striking 100° to 140° and fold hinges plunging 34° southwest. Metamorphic foliation oriented at 050° to 055°/70° southeast is parallel to bedding. Shear zones also cut the Mississagi Formation in this area and vary in width from centimetre- to metre scale. In general, the fabric of the matrix is slaty, highly tectonized and contains blocks of meta-arenite. Within the shear zones the rocks exhibit a strongly foliated, schistose matrix that encloses rotated blocks of meta-arenite in the largest shears and centimetre-scale lozenge-shaped quartzite in small-scale shear zones. It is conceivable that the large-scale zones may represent Sudbury breccia (unit 19).

A unit of white-mica schist (unit 13d), approximately 100 m wide (apparent thickness), is exposed proximal to the Ess Creek fault on its south side. The schist is bounded to the south by mafic metavolcanic rocks, however, the contact between the schist and the metavolcanic unit is not exposed. The white-mica schist is fine- to medium-grained and consists of quartz, feldspar and white mica. Both fresh and weathered surfaces are light greenish-grey. The schists exhibit a discontinuous banding, on a centimetre scale, which consists of 1) white mica-rich zones that form bands 0.5 to 1 cm thick and have boudinaged, flattened quartz lenses and ribbons (some of which could be interpreted as quartz veins on a large scale); and 2) quartz-feldspar rich layers which are more massive, foliated and contain less white-mica. Murphy (1999, 2001) interpreted this compositional layering as an indication that the unit was originally bedded and was subsequently tectonically deformed due to shearing along the Ess Creek fault. The rocks of this unit exhibit strong foliation that may represent stages in formation of protomylonite. These rocks exhibit greenschist-facies metamorphic grade based on the mineral assemblage described above, however, this could also be a local retrograde event and not necessarily the same greenschist-facies regional metamorphism that affects rocks of the Bruce and Mississagi formations immediately adjacent in the Southern Province. The white-mica schist unit has the chemical signature of the Mississagi Formation hence its designation on the map as a subunit of the Mississagi Formation.

Within the Grenville Province, compositionally layered metawackes and metapelites show well developed reverse grading due to preferentially development of kyanite and garnet in the metapelite layers (Photo 13). These rocks were assigned to the Mississagi Formation (units 13c, 13e) on Map P.3427 (back pocket) on the basis of their bedding characteristics, however the geochemistry of these rocks (*see* Figure 30b and samples 96RME-0183 and 96RME-0184, Appendix 1) suggests that these rocks might be more properly assigned to the Pecors Formation (unit 12c).

Quirke Lake Group

BRUCE FORMATION (UNIT 14)

In the Southern Province in Street Township, the Bruce Formation (unit 14) (Collins 1914) is exposed mainly north of the Airport fault and east of the Wanapitei River. It constitutes the basal formation of the Quirke Lake Group and is in conformable contact with the underlying Mississagi Formation and the overlying Espanola Formation. Thickness estimates vary considerably, ranging from more than 1000 m in Falconbridge Township (Debicki 1990) to 335 m in Street Township east of the Wanapitei River (Debicki 1990) to 200 m near Ashigami Lake (Dressler 1982).

Matrix-supported conglomerates constitute most of the Bruce Formation in Street Township. The clasts range in size from less than 1 cm to about 50 cm, however, most clasts are 2 to 5 cm across and normally constitute 5 to 15% of the rock. The clasts are angular to rounded and, in the following order of decreasing abundance, consist of quartz, coarse-grained granite, pyritic gabbro, metasedimentary rocks, metavolcanic rocks and quartz arenite. Pebble size fragments are also common. No clast sorting or preferred orientation of clasts was observed. The matrix consists of very fine-grained, dark grey to grey-brown wacke or a fine- to medium-grained, grey to grey-brown wacke that is dark grey and rusty grey to brown on weathered surfaces. The matrix consists of quartz, feldspar, rock fragments, chlorite, epidote, white mica and opaque minerals. Locally the unit is calcareous. Pyrite and iron oxides are commonly present and result in oxidized rusty weathering patches. Bedding features are rarely observed.

The contact between the Bruce Formation and the underlying Mississagi Formation is exposed in the Timmins Creek area. The proportion of silty arenite beds increases in proximity to the contact, within the Mississagi Formation, and gradually changes across a distance of 10 to 25 m into a zone of interbedded siltstone, arenite and pebbly wacke followed by a thick sequence of conglomerate. The presence of Sudbury breccia bodies and quartz veining near the contact tends to obscure the transition between the two formations. Similar contact relationships were described by Debicki (1990) in Dryden and Falconbridge townships.

ESPANOLA FORMATION (UNIT 15)

In Street Township, the Espanola Formation (unit 15) (Collins 1925) is exposed in the Southern Province mainly north of the Airport fault and east of the Wanapitei River. It constitutes the middle formation of the Quirke Lake Group and is in conformable contact with the underlying Bruce Formation and the overlying Serpent Formation. Thickness estimates of the Espanola Formation vary and range from less than 10 m in parts of Falconbridge Township (Dressler 1987) to roughly 100 m in Street Township, east of the Wanapitei River (Debicki 1990). Three intergradational members are present within the formation; from lowest to highest these are 1) a very thinly bedded calcareous siltstone to wacke containing about 15% carbonate; 2) a thinly to medium bedded, coarser grained, more carbonate-rich middle member; and 3) a very thinly bedded calcareous siltstone to wacke upper member containing about 10% carbonate (Debicki 1990). The formation is poorly exposed in Street Township and was only observed in three locations, one of which consisted mainly of a large Sudbury breccia body containing fragments of Espanola Formation calcareous wacke and calcareous siltstone.

The formation includes grey, pink, white and mottled calcareous to dolomitic limestone (Debicki 1990), however, none of these rocks were observed in Street Township. Very thinly bedded to thinly bedded calcareous siltstone (Photo 14) and calcareous wacke to calc-arenite were the rock types most commonly observed in Street Township. Exposure was not sufficient to assign any of the observed rocks to the members of the Espanola Formation. The calcareous siltstone is composed of angular quartz and

feldspar grains set in a matrix of chlorite, white mica and carbonate. The calcareous wackes are composed mainly of chlorite, white mica, epidote and fine-grained quartz and feldspar.

SERPENT FORMATION (UNIT 16)

Rocks of the Serpent Formation (unit 16) (Collins 1913) underlie much of Street Township south of the Airport fault. The unit is generally poorly exposed on the west side of the Wanapitei River, but is well exposed in ridges along the east shore of the Wanapitei River, north of Leblanc Creek. In the map area, the Serpent Formation consists predominately of arenite and feldspathic arenite with subordinate amounts of pebbly conglomerate. The minimum thickness of the formation in Street Township is 670 m (Debicki 1990), but is closer to 950 m when the section measured by Debicki is extended to the Wanapitei River.

The sandstones of the Serpent Formation are fine- to medium-grained, white-grey to grey to pink feldspathic arenite and arenite. The unit is medium- to thick-bedded. Most beds are massive and bedding planes are gradational and very indistinct. Some parallel laminations, planar-cross laminations with shallow forsets and rare trough cross-beds are present. Conglomerate beds occur locally within the formation and consist mainly of subrounded arenite pebbles up to 5 cm in size set in a medium-grained arenite matrix. The conglomerate beds are commonly channelized.

In thin section, the arenite is composed of 30 to 55% quartz, 25 to 40% feldspar (of which 20 to 35% is potassium feldspar), 0 to 10% lithic fragments and 1 to 20% fine-grained white mica in-filling between quartz and feldspar grains. Carbonate is present in some samples.

Cobalt Group

GOWGANDA FORMATION (UNIT 17)

The Gowganda Formation (unit 17) (Collins 1917) is the basal formation of the Cobalt Group and is a heterogeneous sequence of conglomerate, mudstone and arenite. It is a thick and extensive unit exposed from Sault Ste. Marie to the Cobalt area. It is the only unit of the Cobalt Group present in the Southern Province in the map area. In the Sudbury to Cobalt area, the Gowganda Formation is divided into 2 members: 1) the Coleman member consisting of conglomerate-mudstone-wacke; and 2) the Firstbrook member consisting of mudstone (Thomson 1966; Robertson, Card and Frarey 1969). Only the lower part of the Coleman member is present within Street Township. As noted by Dressler (1982) and Debicki (1990), the contact between the Gowganda and the Serpent Formations may be a transgressive unconformity. Debicki (1990) also suggests that folding (F_1?) of the underlying rock units occurred prior to deposition of the Gowganda Formation. Easton et al. (1996) suggested that the distribution of the Gowganda Formation in Street Township was largely the result of this unconformable relationship and downplayed the effects of folding on the distribution of these rocks. As outlined in "Structural Geology", the distribution of the Gowganda Formation in Street Township is largely related to the exposed structural level of regional folds (F_2) as influenced by subsequent faulting.

Matrix-supported conglomerate constitute most of the Gowganda Formation in Street Township (Photo 15), especially the area south of the Airport fault. Dressler (1982) observed that conglomerate occurs mainly near the base of the formation and may be no more than 100 m thick. The clasts in the conglomerates range in size from less than 1 cm to about 50 cm and normally constitute 5 to 10% of the rock (Photo 15). The clasts are angular to rounded and, in the following order of decreasing abundance, consist of granitic rocks, gabbroic rocks, quartz arenite, metasedimentary rocks and metavolcanic rocks. The granitic clasts commonly make up more than 90% of the clasts that are present. No clast sorting was observed in the map area. The matrix consists of greenish grey wacke and consists of quartz, feldspar,

rock fragments, chlorite, epidote, white mica and opaque minerals. Arenite-filled channels are present within Gowganda Formation conglomerate and indicate stratigraphic tops to the west on the west shore of the Wanapitei River. The Gowganda Formation consists mainly of thinly laminated mudstone to wacke locally containing subangular dropstones of granitic clasts, north of the Airport fault.

NIPISSING GABBRO (UNIT 18)

Rocks of unit 18 constitute the Nipissing intrusive suite. These rocks commonly form sill-like bodies that intrude the Huronian Supergroup at a variety of stratigraphic levels but most commonly near the base of the stratigraphic succession and into the Gowganda Formation. Rocks of the suite consist mainly of gabbronorites and olivine gabbronorites. Rocks of the Nipissing intrusive suite were originally mapped as Sudbury gabbro, consequently, the sills are commonly referred to as Nipissing gabbro. Rocks of the Nipissing intrusive suite commonly exhibit sub-ophitic to ophitic texture, and in the past, have been termed Nipissing diabase even though the rocks are generally far too coarse-grained to be a true diabase. The study by Lightfoot and Naldrett (1996) on the Nipissing gabbro summarizes the typical petrographic, stratigraphic and geochemical characteristics of the suite, and the reader is referred to this publication for more detailed regional information.

Within the Southern Province portion of Street Township, Nipissing gabbro is mainly exposed in the southwest corner of the township where a gabbro sill has intruded the lower part of the Serpent Formation near the Bruce–Serpent Formation contact. Here, the sill has a wedge-shaped form that tapers to the north-northeast until it pinches out. This map pattern may reflect the original form of the body with the tapered wedge reflecting one end of the sill. Both the basal and upper contacts of the sill and the adjacent Serpent Formation quartz arenites are exposed. Contacts between these rocks are sharp with a fine-grained chill margin in the Nipissing gabbro and a "baked" zone in the metasedimentary rocks at the contact. No obvious bottom to top textural variation was noted in the gabbro, however, such variation might be documented if one were to measure a stratigraphic section across the best-exposed part of the intrusion. Several exploration pits, of unknown age and ownership, containing massive sulphides are present near the stratigraphic base of the intrusion (Street occurrence 1, Map P.3427). Midway Mines and Energy Limited examined several soil geochemistry anomalies that were detected along the stratigraphic top of the intrusion for nickel-copper sulphide mineralization (*see* "Economic Geology"). Both areas of sulphide mineralization are located near a major west-northwest-striking fault that offsets the gabbro to the east. It is probable that some of the mineralization in this part of the intrusion may be related to the fault, especially since the mineralization is associated with hydrated gangue minerals including asbestiform-tremolite (*see* "Economic Geology").

The typical Nipissing gabbro is an equigranular, fine- to medium-grained, grey to dark greenish grey weathering rock. Orthopyroxene-rich varieties tend to weather grey and possess a "sugary" recrystallized texture. In thin section, plagioclase constitutes 45 to 55% of the rock with roughly equal amounts of clinopyroxene (15 to 25%) and orthopyroxene (15 to 25%). Green hornblende commonly rims both clino- and orthopyroxene in less thoroughly recrystallized samples. Other primary minerals include biotite, apatite, titanite, opaque minerals and quartz. Secondary minerals include actinolite, epidote, white mica, carbonate and chlorite. In many areas, secondary minerals have thoroughly replaced the primary mineralogy.

Debicki (1990), in measured sections in adjacent Falconbridge Township, reported Nipissing gabbro sills that intruded the lower Bruce Formation and the lower Serpent Formation. This relationship is also apparent on the map of Falconbridge Township (Dressler 1987). The work of Debicki (1990) and Dressler (1987) indicates the presence of two separate sills, at different stratigraphic levels, that serve as useful marker horizons. This relationship was not previously utilized for stratigraphic analysis in Dryden,

Falconbridge and Street townships. It is apparent from the regional map pattern (Dressler 1984a) that both the Nipissing sills documented by Debicki (1990) are folded about a regional antiformal syncline indicating that some regional folding occurred after the emplacement of the Nipissing gabbro (*see* "Structural Geology"). This relationship to folding also means that stratigraphic facing in the adjacent Huronian strata can be used to determine top and bottom within a particular Nipissing sill, which is important when exploring for magmatic nickel-copper-PGE mineralization using basal-contact exploration models.

Another Nipissing gabbro sill is present in the Southern Province in the extreme northeast corner of Street Township and in adjacent Scadding Township. In this area, the sill intrudes conglomerate of the Gowganda Formation. Both the Nipissing gabbro and the Gowganda Formation rocks are in fault contact with Mississagi and Bruce formation strata to the south.

Nipissing gabbro sills are restricted mainly to a 2 to 3 km wide zone south of the Ess Creek fault, within the Grenville Province, east of the Upper Wanapitei River fault. The sills are restricted to a 250 to 500 m wide zone adjacent to the Grenville Front boundary fault. The difference in thickness of these sills, on either side of the Upper Wanapitei River fault, is probably related to stratigraphic truncation due to faulting with the Grenville–Southern Province boundary zone. In the boundary zone east of the Upper Wanapitei River fault, the Nipissing sills intrude metasedimentary rocks that are correlated with the Pecors and Mississagi formations (Murphy 1999, *see* "Pecors Formation" and "Mississagi Formation"). These stratigraphic units overlie or are intruded by gneissic granite and granitic gneiss of unit 9, and as such, the Nipissing sills were emplaced near the basal Huronian Supergroup unconformity. The Nipissing sills were probably emplaced mainly into metamorphosed Huronian strata and not into rocks of the underlying Archean basement.

A variety of textural changes occur within the Nipissing sills with increasing distance into the Grenville Province. Immediately south of the Ess Creek fault, the Nipissing bodies partially preserve the varitextured appearance common to the sills in the Southern Province. A strong preferred orientation of mafic minerals is developed within the sills near their margins and primary pyroxene is converted to amphibole. South of the Grenville Front boundary fault, the Nipissing rocks are amphibolites and contain a well-developed planar fabric, which is parallel to compositional layering fabrics in adjacent host rocks. Garnet is rarely developed within any of the Nipissing equivalents south of the Ess Creek fault. Most of the surrounding rock units contain considerable leucosome, including the gneissic granites of unit 9. However, leucosome rarely occurs in the Nipissing rocks within the Grenville Province. The identification of these bodies as metamorphosed Nipissing sills is based on a combination of outcrop appearance and geochemistry. Both are reliable criteria when the sills exhibit the typical Nipissing chemistry (*see* "Geochemistry of Nipissing Gabbro")). However, it is very difficult to separate them from mafic rocks of the East Bull Lake intrusive suite (unit 7) when the sills exhibit the high-magnesium chemistry common to many Nipissing sills in the Southern Province in the Sudbury region (Easton and James 1997c). In hand specimen, rocks of the East Bull Lake intrusive suite typically contain greenish-pyroxene grains in addition to black hornblende. Only those bodies, within the Grenville Province, that can be identified with a high-degree of confidence as being related to the Nipissing suite are designated as unit 18 on Map P.3427 (back pocket). It should be recognized that some bodies shown on the map as unit 7 may in fact be Nipissing sills. From a mineral exploration standpoint, both high-magnesium rocks of the Nipissing and East Bull Lake intrusive suites are favourable targets for nickel-copper-PGE mineralization.

Geochemistry of Nipissing Gabbro

Samples of Nipissing gabbro sills, collected from Street Township, and analysed during this study are listed in Appendix 1. Chemical variation of the Nipissing sills is illustrated in Figures 8a, 8b and 34.

Previous geochemical studies of the Nipissing intrusive suite (Lightfoot and Naldrett 1996) have focussed on intrusions in the Cobalt plate of the Southern Province which are dominated by rocks having moderate MgO contents (7 to 9 wt.%). In the Sudbury area, as noted by Easton and James (1997a, 1997c), intrusive rocks of the Nipissing intrusive suite are divided roughly equally into two types on the basis of MgO content: 1) a moderate MgO group (4 to 8 wt.%, average Mg number of 54 to 59); and 2) a high MgO group (>9 wt.%, average Mg number of 68 to 77) (*see* Figure 8a, 8b). Rocks of the high MgO group are hypersthene normative and correspond to the hypersthene gabbros locally described within Nipissing intrusions present within the Cobalt plate (e.g., Hriskevich 1968; Conrod 1988, 1989; Lightfoot and Naldrett 1996).

In addition to the data presented by Easton and James (1997a, 1997b), reanalysis of geochemical data collected by La Tour (1979) from 4 Nipissing gabbro sills straddling the Grenville Front, south of Coniston, shows a similar division into a moderate-MgO and a high-MgO group. On major element plots, such as an AFM and Jensen diagram (*see* Figure 8a and 8b), the two chemical groups show distinct differentiation trends within individual sills. On both the AFM and Jensen diagrams, the moderate MgO group exhibits a typical tholeiitic differentiation trend toward higher iron content with increasing silica (*see* Figure 8a and 8b). In contrast, the high MgO group exhibits a more moderate iron enrichment trend on the AFM plot (*see* Figure 8a) and a trend toward lower MgO and alumina contents on a Jensen diagram (*see* Figure 8b).

The two groups of Nipissing gabbro bodies also have distinct trace and rare earth element contents (*see* Figure 34). The high MgO group has higher chromium and nickel contents than the moderate MgO group. In addition, the high MgO group has lower total rare earth element abundances and near flat rare earth element patterns at roughly 10 times chondritic abundances (*see* Figure 34b). The moderate MgO group exhibits more light rare earth element enrichment which may reflect more interactions between the parental magma and continental crust prior to sill emplacement (*see* Figure 34a). Figure 34c shows the variation in rare earth element content between 2 different Nipissing sills studied by La Tour (1979). Both show increasing rare earth element abundances with increasing differentiation as reflected in decreasing Mg number (*see* Figure 34c).

In terms of economic potential, intrusions of the high MgO group of the Nipissing intrusive suite have higher nickel-copper-platinum group element mineral potential as a result of their more primitive chemical character and their overall higher nickel content. Background levels for gold, chromium, copper, nickel, palladium and platinum from Nipissing intrusions in the study area are provided in the "Economic Geology" section.

SUDBURY BRECCIA (UNIT 19)

Sudbury breccia refers to unusual, irregular or crudely tabular breccia bodies that occur within the host rocks to the Sudbury Structure. Dressler (1984b) provides a detailed overview of these rocks. The breccias are generally regarded as being a product of the meteor impact event that formed the Sudbury Structure, presumably the result of shock-wave propagation through the host rocks although a variety of other non-impact mechanisms have also been proposed (see summary in Dressler 1984b).

In Street Township, Sudbury breccia (unit 19) occurs only within the Southern Province, mostly near the Falconbridge-Street township boundary, and within parts of the Mississagi Formation exposed along the Wanapitei River (Photo 16). The occurrence of Sudbury breccia and other impact-related features, such as shatter cones, increases to the west in Street Township and appears to be directly related to proximity to the Sudbury Structure.

Contacts between the Sudbury breccia and the host rocks are sharp. The fragments in the breccia are of the same rock type as the host rock, although locally, exotic fragments have been reported (Dressler 1984b). Within Street Township, no exotic fragments were noted in any of the breccia bodies examined by field party personnel. In hand specimen, the Sudbury breccia matrix is grey or dark grey. The size of the fragments in the breccia depends on the size of the bodies with larger fragments occurring in larger bodies (Dressler 1984b). Contacts between the matrix and the fragments are sharp, however, small matrix apophyses invade fractures in the host rock and fragments. The matrix consists mostly of microscopic and submicroscopic rock flour (pseudotachylite).

Sudbury breccia has not been recognized within the Grenville Province. As Sudbury breccia has been recognized up to 80 km away from the Sudbury structure (Dressler 1984b), proximity to the Sudbury structure would not solely account for its absence in the Grenville Province. It is possible that the appearance of the Sudbury breccia might be different in the Grenville with the fine-grained pseudotachylite being recrystallized during regional metamorphism into a coarser grained rock. If this were the case, then it might be difficult to distinguish Sudbury breccia from agmatitic and other breccias within the Grenville gneisses. A few possible candidates for such a rock occur between the Wanaiptei River and the Kugakami Lake road in Street Township and are hosted in metasedimentary rocks that are likely equivalents of the Mississagi Formation. Although the two-dimensional distribution of the Sudbury breccia is well known, the three-dimensional distribution of the breccia is unknown. If the three-dimensional distribution of the breccia were tabular, not radial, then Sudbury breccia may not have been present at the structural level now represented by the rocks currently exposed in the Grenville Province.

Mesoproterozoic

MAFIC INTRUSIVE ROCKS (SUDBURY DIABASE DIKE SWARM) (UNIT 20)

Several olivine diabase dikes of the 1238±4 Ma (Krogh et al. 1987) Sudbury dike swarm (unit 20) occur within the Southern Province in Street Township. The dikes generally strike 300° to 310° and vary in width from 15 to 35 m. The olivine diabase is commonly medium-grained, but becomes coarser grained in the cores of thicker dikes. Fine-grained to aphanitic, plagioclase porphyritic chill margins occur at the contacts between the dikes and the host rocks. The medium-grained rocks are dark, bluish grey on fresh surfaces and weather brown. The dikes commonly occur near major northwest-striking faults, but do not show any deformation that can be attributed to faulting. Several dikes of this swarm, present in Falconbridge Township (Dressler 1987), may continue into Street Township along the Leblanc Creek fault and in the area between the Leblanc Creek and Airport South faults (*see* Figure 6).

Tectonically disrupted dikes of this swarm occur in 3 areas of the Grenville Province, within Street Township, and likely more dike fragments exist within the map area. Most are found in Domain 2, east of the Ecosource Garnet Ltd. exploration pits, where 4 dike fragments are exposed (Map P.3427, back pocket). In the largest dike fragment, the original chill margin contains equigranular garnet grains with the contact cutting across migmatitic layering in the host gneisses. Other contacts with the dike are not exposed in the area. In hand-specimen, the medium-grained core of the dike appears unaffected by deformation or metamorphism. In thin section, the rock contains thin (50 to 100 μm) amphibole-spinel

coronas around garnet and pyroxene and biotite rims around opaque oxide grains. These coronas are similar to those reported by Bethune and Davidson (1997) from their zones 2 and 3, which were located within the Grenville Front tectonic zone, up to 4 km inboard of the Grenville Front.

A single Sudbury swarm dike from the Grenville Province in Street Township, was sampled for analyses (sample 96RME-0082, Appendix 1; *see* Figure 35). Bethune (1993) and Ketchum and Davidson (2000) used a Sr–Ba–Zr plot to discriminate Sudbury swarm dikes from other mafic intrusive rocks in the region. As illustrated in Figure 35a, the sample from Street Township, as well as other dike samples collected by the senior author in the River Valley area, plot within the Sudbury dike field. Rare earth element patterns in Figure 35b indicate that the sample from Street Township, as well as 8 other Sudbury swarm dike samples from the River Valley area, exhibit relatively flat rare earth element patterns with little or no Eu anomaly and have moderate total abundances. These patterns are similar to results reported by Bethune (1993) and Ketchum and Davidson (2000) for Sudbury swarm dikes from both the Southern and Grenville Provinces.

The Sudbury swarm dikes are important time-markers within the Grenville Province because they indicate that migmatitic layering was present in their host rocks prior to 1238 Ma. In addition, the dikes (and their country rocks) were subsequently affected by high-grade Grenvillian metamorphism that resulted in the development of corona textures in the dikes. The mineralogy present in the coronas is consistent with the upper amphibolite facies metamorphic conditions determined for other rock units within Street Township (*see* "Metamorphism").

DIATEXTITIC GNEISSES (UNITS 21, 22, 23)

Introduction

Diatextitic gneisses within the map area are divided into 3 main compositional groupings: 1) mafic to intermediate migmatitic gneisses (unit 21); 2) intermediate to felsic migmatitic gneisses (unit 22); and 3) quartzofeldspathic migmatitic gneisses (unit 23). All the diatextitic gneisses of units 21 to 23, contain least 2 generations of leucosome, with the older one being thinner, regular, and of tonalitic composition, and the younger one being thicker, irregular, and generally of granodioritic composition (Photos 17, 18, 19, 20, 21). Again, in all the diatextitic gneisses, garnet is evenly distributed between the mesosome and leucosome phases, is not oriented or rotated, and appears to have developed late with respect to regional deformation (Photo 20).

The origin of these 3 diatextitic gneiss units is problematic. In some localities in Street Township, it is possible to regard some of these rocks as highly migmatized equivalents of the other Neoarchean rock units (i.e., parts of unit 21 could be equivalent to units 1 and 4 and parts of unit 23 could be equivalent to unit 2). This interpretation is strengthened by the presence abundant mafic and metawacke pods, similar in appearance to rocks of units 1, 2 and 4, within diatextitic gneisses of units 21 and 23. Diatextitic gneiss of unit 22 has no directly recognizable, less migmatized equivalent, however, it could represent migmatized granodioritic to tonalitic intrusions of Neoarchean age that intruded migmatitic to metatextitic gneisses of units 1 to 4. Alternatively, some diatextitic rocks within unit 22 could represent highly migmatized, and more intermediate composition, equivalents of the Paleoproterozoic gneissic granites of map unit 9. At present, there is no way to distinguish between these two scenarios in the absence of geochronological or geochemical evidence.

In plan view, diatextitic gneisses of units 21 to 23 give the appearance of enveloping all other rock units found within the Grenville Province in Street Township, most notably; the migmatitic to metatextitic

gneisses of units 1 to 4 and several ages of mafic to felsic intrusive rocks, including Neoarchean gneisses (unit 5), Paleoproterozoic gneisses (units 7 to 9), and younger mafic intrusive rocks of Nipissing (unit 18) and Sudbury age (unit 20) (Map P.3427, back pocket). In outcrop, diatextitic gneisses of units 21 to 23 commonly contain subrounded to angular blocks of mafic gneiss and rusty-weathering metasedimentary rocks ranging from 50 cm to 6 m in size. Incorporated blocks are most common near contacts with less migmatized rock units (units 1 to 8), however zones rich in entrained blocks are present in the east-central part of the township. In many parts of the township, but especially in the east-central part, large outcrop areas of older units (units 1 to 8) that are enveloped by diatextitic gneisses of unit 21 and 23 contain older relict gneissic fabrics. In the east-central part of the township, these older fabrics generally show a 070 to 090° strike, in contrast to the dominant 000 to 040° trend present in the enveloping diatexitic gneisses.

Mafic to Intermediate Migmatitic Gneisses (Unit 21)

Mafic to intermediate diatextitic gneisses (unit 21) consist mainly of biotite-garnet amphibolite gneisses with more than 20% leucosome (Photo 17). Rocks of unit 21 are commonly spatially associated with rocks of either unit 1, 4 or 7 (Map P.3427, back pocket). They differ from mafic gneiss of unit 1 in 3 key respects. 1) Rocks of unit 21 generally show evidence of two leucosome phases, one being thinner and tonalitic in composition, the other being thicker, granodioritic in composition and more irregular in appearance. 2) In rocks of unit 21, both the leucosome and the mesosome contain garnet, whereas in rocks of unit 1, garnet is more prevalent in the mesosome. 3) In hand samples rocks of unit 1 generally contain little visible biotite in the mesosome. Some outcrops of unit 21 contain less migmatized ovoid pods, between 50 and 500 cm in size, of either mafic gneiss (unit 21c); pods of unit 7 or 8 rocks (unit 21d); or pods of rusty-weathering metawacke or meta-arenite (unit 21e). The origin of these pod-bearing zones is unknown. They could represent recrystallized and migmatized shear zones or extremely boudinaged layers of rock units that were more resistant to partial melting.

Intermediate to Felsic Migmatitic Gneisses (Unit 22)

Intermediate to felsic diatextitic gneisses (unit 22) range from granodiorite to monzogranite in bulk composition and contain more than 20% leucosome (Photo 18). Leucosome layers are generally thin (<2 cm thick) and closely spaced. Unit 22 is the least abundant of the diatexitic units. Some outcrops of unit 22 contain less migmatized ovoid pods as in unit 21.

Felsic Migmatitic Gneisses (Unit 23)

Felsic diatextitic gneisses (unit 23) (Photos 20, 21, 22) are the most areally abundant of the 3 diatexitic gneiss units. Whereas rocks of unit 21 could be derived from metatextitic gneisses of unit 1 or 4, and rocks of unit 22 could be derived from granitoid orthogneisses, there is no obvious protolith for most of the rocks present within unit 23. Some outcrops of unit 23 contain less migmatized ovoid pods between 50 and 500 cm in size of either mafic gneiss (unit 23b) or mafic layers (unit 23de), pods of mafic gneiss resembling rocks of unit 4 (units 23f, 23g), pods of mafic gneiss resembling rocks of unit 7 (unit 23k), or pods of rusty-weathering metawacke or meta-arenite and (unit 23c). As was the case for unit 21, the origin of these less migmatized pods or layers is not known.

In a few localities within Street Township, and in Awrey and Dryden townships to the southwest, some rocks within this map unit contain clasts that do not represent disrupted leucosome layers (Photo 22), and which may indicate that parts of unit 23 represent migmatized metaconglomerates. This relationship is best exposed in an abandoned gravel pit located 500 m north of Highway 17 in Dryden

Township, immediately adjacent to Sunset Road, and located roughly 750 m southwest of the southwest corner of Street Township. In this quarry, metaconglomerate layers preserved in fold noses grade abruptly into diatexitic gneiss typical of unit 23. The metaconglomerate beds are matrix- to clast-supported and contain a higher proportion of clasts than do many of the Huronian Supergroup conglomerate units, consequently, correlation of the metaconglomerates in the gravel pit and within unit 23, does not appear likely. Whether the presence of some metaconglomerate layers within unit 23 rocks indicates that the entire unit is of metasedimentary origin cannot be determined.

Origin and Tectonic Significance

The current working hypothesis is that the diatextitic gneisses of units 21 to 23 represent migmatized equivalents of rock units 1 to 8. The older, regular, tonalitic leucosome within units 21 to 23 may represent the Neoarchean migmatization event that has already been noted as being present in rocks of units 1 to 5, but not in mafic rocks of the East Bull Lake intrusive suite (units 6 to 8). The younger, more irregular, granodioritic leucosome within rocks of unit 21 to 23 is suspected to be Grenvillian in age. The abundance of leucosome may reflect that once the rocks in the region were heated to peak metamorphic conditions, they remained there for some period of time. This lengthy period at high temperatures was likely instrumental in the development of large garnet grains throughout all phases of the rock (mesosome and leucosome).

In many respects, diatextitic gneisses of units 21 to 23 resemble the prodigious development of migmatitic rocks immediately above the allochthon boundary thrust belt in the Central Gneiss Belt of the Ontario Grenville Province (e.g., Culshaw et al. 1997; Carr et al. 2000). Upward migration of fluids during tectonic transport along the allochthon boundary fault is one mechanism that has been suggested for the origin of these "juicy" migmatites (Culshaw et al. 1997). It is possible that a similar mechanism may have occurred in Street Township. If this were the case, then rocks of Domains 1 and 2 would represent non-migmatized parts of a deformation zone associated with the Grenville Front deformation zone, whereas rocks of domain 3 (mainly rocks of unit 21 to 23) would represent rocks in the immediate hangingwall of the Grenville Front. The migmatites of units 21 and 23, within Domain 3, would have formed in response to upward migration of fluids from the Grenville Front into rocks that had been heated and deformed during the Grenville Orogeny. This migmatization event would also explain the development of Grenville-age migmatitic textures in rocks of unit 9.

What is unclear, however, is why rocks of the East Bull Lake intrusive suite, found as large enclaves within Domain 3, are not migmatized as well? Were rocks of unit 6 to 8 simply more resistant to partial melting because of their bulk-rock composition? Or were rocks of unit 7 and 8 tectonically emplaced from a region that was not subjected to this migmatization event? At present, there is no compelling evidence for tectonic emplacement of unit 7 and 8 within Domain 3. In contrast, there is some evidence, such as the presence of blocks of unit 7 and 8 rocks in unit 23, that rocks of unit 7 and 8 may have simply been more resistant to partial melting.

MYLONITIC ROCKS AND TECTONITES (UNIT 24)

This unit includes highly deformed Mesoproterozoic rocks that are found along the northern contact of Domain 1 and along the Grenville Front boundary fault and the Ess Creek fault. The largest exposure of rocks of unit 24 occurs in southwest Street Township on the south shore of the Wanapitei River (Map P.3427, back pocket), immediately adjacent to the Grenville Front. In this area, a 100 m wide belt of porphyroblastic and straight gneisses derived from rocks of units 1, 2 and 4 is present. Davidson (1998)

has reported the presence of similar zones immediately adjacent to the Grenville Front to the southwest of the study area in Dryden and Dill townships.

In contrast to these ductile deformed rocks (units 24a, 24b, 24c), brittle deformed rocks (unit 24d) also occur in the map area, mainly along the Grenville Front boundary fault. Unit 24d consists of fine-grained to ultramylonitic, chloritized and hematized rock that is generally microfractured and friable. It is observed in zones less than 2 to 3 m wide, although hematization associated with unit 24d may extend for 5 to 10 m on either side of these rocks. In the Timmins Creek area, the Grenville Front boundary fault transects granitic rocks of unit 9, and it is likely that the fault gouge (unit 24d) in this area is formed from unit 9 rocks. This is confirmed by 2 chemical analyses from this area. Sample 96RME-3015 (Appendix 1) is a fault breccia of granitic composition present along the trace of the Grenville Front boundary fault, whereas sample 96RME-3036 (Appendix 1) is fault gouge collected from the trace of the Grenville Front boundary fault. Both samples show chemical traits consistent with the derivation from unit 9 rocks.

FELSIC INTRUSIVE ROCKS (UNIT 25)

Granitic pegmatite dikes of 2 generations are recognized in the study area: 1) a syn- to late tectonic variety that is partly deformed with contacts subconcordant to the regional fabric; and 2) a posttectonic variety that is undeformed and crosscuts the regional fabric. There is no apparent difference in the constituent minerals of the 2 generations of pegmatites. The minerals are quartz, feldspar, muscovite and biotite with minor amphibole. Most pegmatites, especially of the posttectonic variety, were observed in Domain 1. Most pegmatites of the syntectonic variety were observed in Domain 3.

The age of pegmatite generation is not precisely known. Corfu and Easton (2000) dated folded granitic leucosome of granitic composition and undeformed granitic leucosome within granitic gneiss of unit 9 and found only a minor difference in age between them (995±3 Ma and 989±2 Ma, respectively; *see* Table 6). Whether or not these ages also reflect the timing of the 2 pegmatite generations is unclear, but it would be consistent with what is known about the tectonic history of the area. As noted previously, Easton (2000) has reported "fertile" granitic rocks of Neoarchean age east of Sudbury near River Valley. These "fertile" granitic rocks are commonly associated with granitic pegmatites and rare-element-bearing pegmatites and it is possible that such Neoarchean pegmatite bodies (which would be deformed) may be present within the Grenville Province in Street Township.

CENOZOIC

Quaternary

PLEISTOCENE AND RECENT

Approximately 20 000 years ago, Street Township was covered by the Laurentide Ice Sheet. Deglaciation of the Sudbury area, approximately 9500 to 11 000 years ago, resulted in the formation of large glacial lakes at the receding glacier margin. The last of these glacial lakes drained approximately 5500 years ago. None of the Quaternary deposits in the study area can be attributed to glacial lake deposition. Significant areas of glaciolacustrine (sand- to gravel-rich) sediments occur in Street Township, most notably along the trace of the Wanapitei River and the Upper Wanaiptei River fault. Sand and gravel quarries are not present in Street Township, but are located along the Kukagami Road immediately south of Street Township.

According to Tardiff (2000), only one till has been identified within the area, and occurs as a veneer overlying bedrock. Ice flow indicators generally indicate flow toward the south (Tardiff 2000; this study). In the southern part of the township, large hills of bedrock have a characteristic form and orientation that may reflect ice flow direction. These hills are steep-sided on their western and southwestern slopes but exhibit more gentle, drift covered slopes to the north and northeast flanks. Where large glacial erratics of distinctive rock units have been observed (unit 6), they generally occur south or southwest of known bedrock exposures.

Swamp and organic deposits are common in low-lying areas within Street Township, particularly along major drainage systems such as Timmins and Leblanc creeks. In many cases, these low-lying areas correspond to fault zones. In the eastern and central parts of Street Township, outcrop areas are only thinly covered and vegetated, likely reflecting the past effects of fume kill from the Coniston and Falconbridge smelting operations that lie upwind of the township. In areas distal to these operations, such as in the northeast part of the township and along the Street-Loughrin township boundary, both lichen and forest cover increases markedly.

Structural Geology

INTRODUCTION

Only a limited interpretation of regional structure is shown on Map P.3427 (back pocket) in the part of Street Township that is underlain by rocks of the Southern Province. As will be made clear in this section, this cautious portrayal of major structural features on the map reflects a variety of field-related uncertainties, including 1) limited outcrop exposure; 2) variations in stratigraphic thickness of Huronian Supergroup units between the west and the northern parts of the map area; 3) lack of exposure of contacts between stratigraphic units thereby making it difficult to determine if contacts are structural or stratigraphic; 4) lack of planar fabrics related to large-scale folding in the Huronian strata; 5) the presence of large areas of matrix-supported conglomerate units which do not readily exhibit small-scale parasitic folding; 6) the interference effects of at least 2 generations of folds; and 7) lack of detailed structural analysis in adjacent townships, in particular, the non-recognition of the effects of superimposed folding. For these reasons, it was decided to make the display of information on Map P.3427 (back pocket) as non-genetic as possible. Nonetheless, using reasonable assumptions, it is possible to make a more detailed interpretation of the structural geology of the Southern Province in Street Township, as discussed below.

The timing of major structural events in Street Township is provided in Table 3. The effect of major regional fault systems on the geology of Street Township has been covered in the section on "Regional Geological Setting" and is not repeated here.

FOLDING: SOUTHERN PROVINCE

Structural Domains in Street Township

Three main structural domains are present in the Southern Province in Street Township, as follows:

1. A southwest domain lies between the southwest corner of the township and the Airport fault. It consists of a stratigraphic section consisting of the Mississagi, Bruce, Espanola, Serpent and

Gowganda formations with a Nipissing gabbro intruded locally into the basal Serpent Formation. In this domain, a north-northeast-trending antiformal syncline to overturned antiformal syncline is the dominant structural element (F_2 fold), along with northwest-striking faults which cut the fold and all stratigraphic units.

2. A northwest domain lies west of the Kukagami Lake road, between the Airport fault and the north boundary of the township. It contains rocks of the Mississagi, Bruce and Espanola formations, folded within a north-northeast-trending anticline (F_1 fold) that is refolded by an east-southeast-trending syncline (F_2 fold).

3. A northeast domain lies east of the Kukagami Lake road, between the Grenville Front and the north boundary of the township. It contains rocks of the Stobie, Pecors (?), Mississagi and Bruce formations, folded within a northeast-trending anticline (F_2 fold?). Limited exposure in this domain and strong parallelism of structural grain with the Grenville Front makes it difficult to determine if contacts are stratigraphic or tectonic.

As outlined in "Regional Geological Setting", and shown in Figure 5, the Huronian Supergroup stratigraphy in the southwest domain is likely thicker overall, especially within the Bruce and Serpent formations. In the northeast and northwest domains, the Bruce and Serpent formations in particular are thinner, with the Espanola Formation showing considerable variation in thickness (100 to 250 m). In the northeast domain, south of the Ess Creek fault, the presence of a thin sequence of metavolcanic rocks correlated with the Stobie Formation and the possible presence of the Pecors Formation is noteworthy.

Regional Considerations

Previous workers (e.g., Dressler 1982, 1984a, 1987) have generally depicted a relatively simple structural picture for the Southern Province in and around Street Township which was dominated by an open, north-northeast-trending syncline, south of the Airport fault; and a broad, west-northwest-trending syncline, north of the Airport fault. Although this simple interpretation is appealing, there are several inconsistencies. 1) Stratigraphic facing and regional dips of units do not match, suggesting either the presence of overturned structures or superposition of folding. 2) The distribution of stratigraphy across faults does not match predictions from a simple open-folding regime. 3) North of the Airport fault, extensive areas underlain by a single formation are not compatible with known unit thickness and measured moderate to steep dips of the respective units.

A re-examination of the map pattern north of the Airport fault, correcting for subsequent fault offsets, and consideration of F_2 folding of Nipissing sills, reveals a classic crescent-mushroom shape fold interference pattern (type 2 interference pattern, Ramsay and Huber 1987), with earlier north-trending F_1 fold axes refolded around more easterly trending F_2 axes. This map pattern also suggests that the Nipissing sills were not subjected to the effects of F_1 folding, even though they were affected by F_2 folding. The superposition of these two folds sets is compatible with the presence of 1) broad areas underlain by a single, thin, stratigraphic unit (e.g., Espanola (~100 m thick) or Bruce (200 to 300 m thick) formations); and 2) the observed moderate to steep (60 to 75°) regional dips. A simple single folding regime is not compatible with these features. Debicki (1990) suggested that folding (F_1?) of the underlying Huronian Supergroup occurred prior to deposition of the Gowganda Formation. If this is the case, the Gowganda Formation may have only been affected by F_2 folding.

The situation south of the Airport fault shows a different pattern due to the fact that this area was likely subjected to type 0-fold superposition (*see* Figure 36). Type 0 interference folds do not produce the geometric features that are commonly held to be characteristic of fold superposition and the resulting three-dimensional geometry is practically identical to that produced during a single phase of deformation

(Ramsay and Huber 1987). This type of fold regime would, however, explain the origin of the antiformal syncline present in west Street Township (shown as a syncline on previous maps by Dressler (1984a, 1987)); consistent with observed stratigraphic facing but not with structural observations (*see* Figure 36). South of the Airport fault, Nipissing sills are affected by folding, although in this area, it is not possible to determine if the sills are affected by only one, or both, periods of folding.

Why the pattern of fold interference changes on either side of the Airport fault can only be speculated upon. It could be related to the presence of a thicker stratigraphic sequence south of the fault that includes more competent metavolcanic rocks near the base of the stratigraphy. Alternatively, it could be related to a thinner stratigraphic sequence and more involvement of underlying basement rocks north of the Airport fault. The geometry of the Sudbury Structure itself also may be a factor, with the location of the Airport fault approximating the asperity in the Sudbury Structure where it changes trend from easterly to northerly. Furthermore, the Airport fault is the likely continuation of the South Range shear zone, a major regional structure, which likely had a major thrusting component with a net displacement of between 8 to 19 km (e.g., Shanks and Schwerdtner 1991; Boerner, Milkereit and Davidson 2000; Boerner and Milkereit 1999).

Jackson (2001) has noted that throughout the western Southern Province, structural complexity is probably far greater than previously recognized and that it is commonly difficult to separate different fold generations, or to correlate their planar fabrics, if they are present. The observations made herein with respect to the Southern Province in Street Township attest to Jackson's (2001) interpretation and suggests that his interpretation applies throughout the Southern Province, not just the area west of Sudbury. From an exploration standpoint, recognition that two generations of folding have affected the rocks, rather than a single generation, has numerous implications with respect to exploration, interpretation of aeromagnetic patterns and the interpretation of diamond-drill hole data.

FOLDING: GRENVILLE PROVINCE

As noted by Murphy (1999, 2001), whose study straddled the Grenville Front in the Timmins Creek area, the complexity of structures increases dramatically south of the Ess Creek fault (Grenville Front). Between the Ess Creek fault and the Grenville Front boundary fault (Lumbers 1973), the most prevalent foliation strikes 060° and dips to the southeast at 70°. This foliation is parallel to both the Grenville Front boundary fault and the Ess Creek fault. All metavolcanic and metasedimentary rocks within this zone contain tight (F_1) folds with axial planes trending 050° to 060° and dipping 60° to 70° southeast. Folding (F_1) is well developed within the garnet-biotite and staurolite-garnet-muscovite ± kyanite schists and is best defined by quartz-feldspar layers or veins within more homogeneous, originally sandy units. Figure 37 demonstrates the relationship between first stage deformation (F_1) and the two structural elements: bedding (S_0) and foliation (S_1) within the area between the Ess Creek fault and the Grenville Front boundary fault (Lumbers 1973). Primary bedding is parallel to subparallel to the foliation (S_1) on the limbs of F_1 folds but bedding and the foliation crosscut each other at the nose of the folds.

South of the Grenville Front boundary fault (Lumbers 1973), banded migmatitic gneisses of unit 21 are present. These migmatitic gneisses are cut by concordant and discordant pegmatites of unit 25. The migmatitic gneisses exhibit tight to isoclinal F_2 folds with axial planes oriented 074° and dipping 70° southeast and plunging 45° southwest. Their attitude is identical to that of F_1 folds immediately to the north of the Grenville Front boundary fault (Lumbers 1973). Figure 38 illustrates schematically the relationship between the S_1 foliation (assumed to be the same as that south of the Ess Creek fault), F_2 folds and pre- and post-F_2 migmatites and pegmatites. The migmatites represent the peak metamorphic conditions during F_1 deformation in the Timmins Creek area. F_2 folds do not have an associated S_2 fabric indicating there was no new growth of metamorphic phases during this second generation of folding. The

simplest explanation for this phenomenon is that F_2 folds formed as a result of the very ductile nature of the metamorphic environment attained during the F_1 event. In short, only one major metamorphic period is present. The presence of a single event is consistent with the geochronology data and cooling history data presented elsewhere in this report. The changes in structural style across the Grenville Front boundary fault (Lumbers 1973) reported by Murphy (1999, 2001) are similar to those reported by Dalziel, Brown and Warren (1969).

Folding style within Domains 2 and 3 of the Grenville Province are characterized by outcrop (Photos 23 and 24) and regional scale (Map P.3427, back pocket) refolded folds, generally of type 1 geometry (Ramsey and Huber 1987). Type 2 refolded folds are also present in some areas, most notably affecting the Street metagabbro in southeast Street Township. Davidson (1998) reports similar fold styles to those shown in Photos 23 and 24 from the Grenville Front tectonic zone immediately southwest of Street Township. In the absence of an established stratigraphic sequence, detailed structural analysis of these folds within the Grenville Province is difficult.

Metamorphism

INTRODUCTION

Rocks of the Huronian Supergroup have likely been subjected to sub-greenschist facies metamorphic conditions. Metamorphic biotite has only been observed in one sample of unaltered Southern Province rocks from the study area near Jackson Lake and is located within 200 m of the Grenville Front. Consequently, this section will focus mainly on the metamorphic conditions observed within Grenville Province rocks in Street Township. Because quantitative thermobarometric data were collected during the course of this study, largely by Murphy (1999, 2001), it is necessary to review the theory and methodology behind this data before discussing the results.

THERMOBAROMETRY

Theory

In thermobarometry the most important factor for the determination of temperatures and pressures is complete equilibration of the relevant mineral assemblage. Measurements of the coexisting mineral compositions are required for quantitative pressure-temperature (*P–T*) calculations. This was done on a JEOL JSM-6400 Scanning Electron Microscope (SEM) using Energy Dispersive Spectroscopy detector located within the Geoscience Laboratories, Geoscience Services Centre, Sudbury. The data were processed using a ZAF-4 correction program. Several criteria needed to be achieved for reliable chemical analyses: (a) careful calibration; (b) use of one or more standards; (c) checking the analytical totals (weight percent); and (d) comparative mineral stoichiometry.

There are several methods to estimate the pressure and temperature of metamorphic reactions. The main principle for all methods is that at a given pressure and temperature the mineral phases are associated with unique values of molar Gibbs free energy (G). Rocks represent heterogeneous thermodynamic systems (Gibbs 1961) where minerals, aqueous fluids and gases are the thermodynamic phases. In the study area, these phases are staurolite, kyanite, garnet, biotite, muscovite, calcium amphibole, plagioclase, quartz, ilmenite, rutile, and water.

Methods

Two approaches have been used in this study to quantitatively estimate the conditions of metamorphism in Street Township. The most rewarding is the use of low variance mineral assemblages that permit the calculation of numerous equilibria whose area of intersection is an estimate of the conditions at which the assemblage formed. TWEEQU (Berman 1991) and INVEQ (Gordon 1996) are software programs used to explore this approach. The second approach is focused on exchange reactions where individually calculated mineral thermometers are used to estimate temperature.

The computer software program TWEEQU – version 1.02 (Thermobarometry With Estimation of EQUilibrium state) was developed by Berman (1991). This program contains a thermodynamic database for a wide variety of end-member minerals and mineral composition solution models for garnet, biotite, plagioclase, white mica and calcium amphibole. The free energy (G) of these minerals at pressure and temperature is calculated from these thermodynamic data using equations of state given by the laws of chemical thermodynamics. According to these laws, the chemical components making up a total rock composition are distributed into a group of homogeneous phases (minerals and fluids), that constitute the assemblage with the lowest free energy for the system for that given pressure and temperature. This assemblage is most stable.

TWEEQU uses the requirement that when products and reactants of a chemical reaction ($\Delta G = G_{products} - G_{reactants}$) are both stable, then $\Delta G_{reaction} = 0$. These conditions are referred to as the equilibrium conditions of the reaction and in pressure-temperature space can be expressed by a single curve. Along this curve all minerals are simultaneously stable and any intersection with related univariant equilibria gives estimates of the temperature and pressure at which the mineral assemblage formed. For any perfectly behaved system (all minerals equilibrate at the same pressure and temperature, reliable mineral composition, standard state and mixing properties) the calculated phase diagram should have all equilibria intersecting at a unique point (Berman 1991). The degree, to which all reaction curves converge to the single point, is ideally directly proportional to the state of equilibrium among the phases. Minor mineral phases, such as rutile and ilmenite, which cause more scatter of the reaction curves in the *P–T* space have been omitted in this study in order to more accurately approach the single convergence point.

Chemical homogeneity of coexisting minerals in the rocks is an important factor for obtaining a best estimate of the equilibration of mineral pairs (assemblages). For this reason, a series of garnet-biotite and plagioclase-amphibole pairs were analyzed to provide data on the homogeneity of these phases (Tables 8, 9). Among many combinations, the data pairs have been divided into two groups. The first group represents analyses of rims of matrix biotite in contact with the rim of garnet. The second group represents core analyses of biotite and garnet grains. This group has been chosen for the *P–T* calculations to avoid late re-equilibration (retrograde) between phases. Both garnet and biotite are relatively uniform in composition. The same two groups involve core and rim analyses of the plagioclase-amphibole pair.

Adjacent mineral pairs were analyzed, because they had the best opportunity to equilibrate. To decrease analytical error, 2 to 3 analyses were done for each mineral phase. Average mineral compositions were used for the final thermodynamic calculations. Core compositions give the highest pressure, temperature determinations indicating that they probably recorded the peak of metamorphism, whereas rim compositions yield the lowest values due to re-equilibration during retrograde metamorphism. In this study, core-generated data are normally reported.

INVEQ (INVerse of chemical EQUilibrium) is a software program available on the World Wide Web and developed by Gordon (1996). The program allows the inverse of the classical "chemical equilibrium problem" to be performed. It allows determination of *P–T*, at which a mineral assemblage

formed, given the composition of mineral phases. The TWEEQU database is used in INVEQ as a source for calculating the thermodynamic activities of components in the relevant minerals.

The main advantage of the INVEQ is the fact that at equilibrium, the partial molar free energies of all end-members should lie on a single plane. In this approach, the pressure and temperature of equilibrium are found by finding the best-fit plane to the partial molar free energies of all end members rather than a set of independent equilibria as calculated by TWEEQU. Murphy (1999) (*see* Table 8) compared the results of calculations using INVEQ with those using the TWEEQU program for the same mineral assemblages and found that the two methods gave similar results.

Geothermometers

Two thermometers were used in this study: garnet-biotite and amphibole-plagioclase. Both are based on the interchange of two similar atoms between different sites in one mineral (amphibole) or between two minerals (garnet-biotite, amphibole-plagioclase). Because the exchange atoms are elements of similar charge and ionic radius the volume changes involved are very small and the entropy changes relatively large (Bucher and Frey 1994). Therefore exchange reactions are largely independent of pressure and therefore are good thermometers.

The garnet-biotite thermometer is based on the magnesium-iron exchange between annite-phlogopite and almandine-pyrope (Hodges and Spear 1982). The amphibole-plagioclase thermometer is based on the coupled substitution Ca + Al = Na (K) + Si where the substitutions in amphibole for alkalis in the A site and Si/Al^{IV} in the T1 site (Holland and Blundy 1994). The actual calculation was done using a Microsoft Excel spreadsheet developed by F.D. Ford (Microprobe Technician, Geoscience Laboratories, personal communication, 1997, 1998).

Results

Results from the Timmins Creek area obtained by Murphy (1999, 2001) are summarized in Table 8. Regional data from Street Township, in part reported by Buckley et al. (1997), are summarized in Table 9. Figure 39 is a petrogenetic grid showing the general *P–T* conditions present within the Grenville Province in Street Township.

In the Timmins Creek area, where a clear progression from the Southern Province into the Grenville Province can be observed (Murphy 1999, 2001), the following textural and geological observations suggest increasing metamorphic conditions to the south, corresponding to increasing distance into the Grenville Province. An increase in metamorphic grade to the south is indicated by 1) grain size increase; 2) textural changes (e.g., from schist to gneiss); 3) a progression in the appearance of metamorphic indicator minerals with high-grade minerals being found to the south (e.g., staurolite, kyanite); and 4) the development of leucosome indicating conditions of partial melting (migmatite formation). The location of first leucosome appearance coincides with the Grenville Front boundary fault (Lumbers 1973). As outlined below, the thermobarometric results also indicate increasing metamorphic conditions with increasing distance into the Grenville Province.

Metamorphic conditions of middle to upper amphibolite facies occur for the domain present between the Ess Creek fault and the Grenville Front boundary fault (Lumbers 1973). Lumbers (1973) assigned this area to the Southern Province, however the age (circa 990 Ma; *see* Table 6) and intensity (upper amphibolite facies) of metamorphism leaves little doubt that this region is part of the Grenville Province. Pressures of 7 to 7.8 kilobars and temperatures of 650 to 690°C are typical for this area. The best estimate of metamorphic conditions of rocks in the Southern Province north of the Grenville Front

Table 8. *P–T* estimates for metapelites, metabasites and granitic rocks from the Timmins Creek area, Street Township (*from* Murphy 1999).

No.	Domain	Sample number	Methods			
			TWEEQU (ver. 1.02)[1] P in kbar, T in °C	INVEQ[2] P in kbar, T in °C	Grt-Bt Thermometer[3] P in kbar, T in °C	Hb-Pl Thermometer[4] P in kbar, T in °C
1	Southern Province Domain	**96RME-0610** metabasite				2.0, 688.9 4.0, 674.0 6.0, 659.2
2	South of Ess Creek fault	**96RME-3004** metabasite	9.7, 627.1			6.0, 619.7 8.3, 646.8
3		**96RME-3005** metapelite	6.7, 630.2		5.5, 636.8 8.0, 646.0	8.0, 646.0
4		**96RME-0124** felsic metavolcanic				6.0, 696.8 8.3, 708.2
5		**96RME-3006** metapelite	7.5, 655.4 6.8, 615.2		5.5, 637.0 8.0, 645.7	
6		**96RME-3031** metapelite			6.0, 623. 8.0, 625.9	
7		**96RME-3008** metagranite			5.5, 679.8 8.0, 688.5	6.0, 724.3 8.3, 726.2
8		**96RME-0232a** metapelite	7.6, 678.0	7.6, 678.0	5.5, 680.1 8.0, 690.3	
9		**96RME-0232b** metapelite	7.8, 645.0			
10		**96RME-3112** metapelite	7.4, 660.0 7.4, 665.0	7.3, 660.0		
11		**96RME-3147** metabasite				6.0, 508.9 8.3, 509.4
12		**96RME-3147-2** metabasite				6.0, 539.0 8.3, 542.4
13	South of GFBF	**96RME-3020** metapelite			5.5, 710.6 8.0, 719.8	
14		**96RME-0242a** metapelite	7.7, 690.0		6.0, 649.8 8.0, 657.7	
15		**96RME-0242b** metapelite	8.1, 685.0	8.1, 685.0		
16		**96RME-0450** metabasite				6.0, 681.0 8.3, 695.6
17		**96RME-3027** metabasite				6.0, 718.5 8.3, 726.5
18		**96RME-3022** granite gneiss	6.8, 713.0		5.5, 718.5 8.0, 727.2	6.0, 757.6 8.3, 751.6
19		**96RME-3148** metabasite				6.0, 684.9 8.3, 688.9
20		**96RME-3149** metabasite				6.0, 714.6 8.3, 730.0
21		**96RME-3150** metabasite				6.0, 693.4 8.3, 700.9
22		**96RME-3151** metabasite				6.0, 696.8 8.3, 708.2

Error range for pressure is ± 1.0 kbar, error range in T is ± 50°C. [1]Berman (1991); [2]Gordon (1996); [3] calibration of Hodges and Spear (1982); [4] calibration of Holland and Blundy (1994), average of edenite-tremolite and edenite-richterite thermometers. GFBF = Grenville Front boundary fault (Lumbers 1973).

Table 9. *P–T* estimates for metapelites and metabasites from Street Township (*from* Buckley et al. 1997).

No.	Key Minerals present	Sample number	Methods			
			TWEEQU (ver. 1.02)[1] P in kbar, T in °C	Grt-Bt Thermometer P in kbar, T in °C F & S[2]	Grt-Bt Thermometer P in kbar, T in °C H & S[3]	Hb-Pl Thermometer[4] P in kbar, T in °C
1		**95RME-0135A** metabasite		6.0, 678, 8.0, 686 6.0, 570, 8.0, 578♦	6.0, 705; 8.0, 713 6.0, 596, 8.0, 603♦	
2		**96RME-0233** metabasite				6.0, 652, 8.0, 678
3	Grt,bt,ms,pl,st	**96RME-0234** metapelite	7.0, 645 6.7, 645 7.0, 668	6.0, 585; 8.0, 592	6.0, 610; 8.0, 618	
4	Grt,bt,ky,pl,	**96RME-0242** metapelite	8.0, 650 8.0, 650 5.9, 613♦	6.0, 638 8.0, 646 6.0, 600, 8.0, 608♦	6.0, 665; 8.0, 673 6.0, 620, 8.0, 628♦	
5	Grt,bt,ms,pl	**96RME-0345** metapelite	8.1, 743 8.1, 743 8.0, 730 8.0, 750	6.0, 789; 8.0, 794 6.0, 722, 8.0, 731♦	6.0, 799; 8.0, 809 6.0, 725, 8.0, 734♦	
6	Grt,bt,ky,pl	**96RME-0408** metapelite	6.9, 625 6.8, 620	6.0, 735; 8.0, 744 6.0, 622, 8.0, 630♦	6.0, 747; 8.0, 756 6.0, 635, 8.0, 643♦	
7	Grt,bt,ky,pl,st	**96RME-0408** metapelite	8.6, 690 8.7, 670			
8	St-zone	**La Tour S136** metapelite	5.4, 600			
9	Sil-zone	**La Tour S142** metabasite				6.0, 692 8.0, 709

Error range for pressure is ± 1.0 kbar, error range in T is ± 50°C. ♦ rim and matrix compositions; [1] Berman (1991); [2] calibration of Ferry and Spear (1978), [3] calibration of Hodges and Spear (1982), [4] calibration of Holland and Blundy (1994), average of edenite-tremolite and edenite-richterite thermometers. Data for samples 8 and 9 are from La Tour 1981, and has been recalculated to facilitate comparison with the results obtained during this study. Abbreviations: bt = biotite, grt = garnet, hbl = hornblende, ky = kyanite, ms = muscovite, pl = plagioclase, P = pressure, sil = sillimanite, st = staurolite, T = temperature.

suggests metamorphic pressures of 1.5 to 3 kilobars and temperatures less than 350°C (Jackson 2001). Thus, across the Ess Creek fault, a zone only tens of metres wide, metamorphic conditions change abruptly by some 4 to 5 kilobars and by at least 300°C.

In contrast, areas within the Grenville Province located south of the Grenville Front boundary fault (Lumbers 1973) are uniformly at upper amphibolite facies and exhibit slightly higher metamorphic pressures and temperatures (7.7 to 8.7 kilobars, 700 to 750°C, an increase of roughly 1 kilobar and 50 to 100°C). These pressure–temperature conditions correspond to middle crustal levels (~25 km). As illustrated in Figure 39, this slight difference in pressure and temperature means that most rocks located south of the Grenville Front boundary fault lie in the field of partial melting. In the Timmins Creek area, this is consistent with field observations that the Grenville Front boundary fault marks the change from non-migmatitic to migmatitic rocks. On a regional scale, it provides an exploration for the ubiquity of migmatitic rocks within the Grenville Province in Street Township.

Two samples from the Timmins Creek area, from north (sample 96RME-3112, Table 8) and south (sample 96RME-0242, Table 8) of the Grenville Front boundary fault best illustrate estimated pressure and temperature conditions of metamorphism with increasing distance into the Grenville Province. These 2 samples, both from metapelites, contain the phases staurolite, kyanite, garnet, biotite, muscovite, plagioclase and quartz. These are the lowest variance assemblages (variance = 1) recognized in these 2 areas. As a result they provide the maximum number of linearly independent reactions (3 anhydrous or 4 if hydrous) to estimate the pressure and temperature.

Six anhydrous phases (kyanite, garnet, biotite, muscovite, plagioclase, quartz) from sample 96RME-3112 produced 3 linearly independent reactions indicating that the sample last equilibrated at $P = 7.35$ kilobars and $T = 660°C$ (using the INTERSX program, TWEEQU) (*see* Table 8). When staurolite and water are included in the calculation, the total number of linearly independent reactions is 4. *P–T* data similar to that obtained from the anhydrous assemblage (i.e., 660°C, 7.35 kilobars) are obtained with a water activity from 1.0 to 0.87. The latter value gives the best fit to the anhydrous calculations and indicates that the fluid that equilibrated with this assemblage was not pure water. Using the same data for the anhydrous phases for this sample, application of the INVEQ program gives similar results of $P = 7.3$ kilobars, $T = 660°C$ with error estimated at 1 kilobar and 50°C, respectively (Murphy 1999, 2001).

For sample 96RME-0242, and using the same anhydrous phases as for sample 96RME-3112, the convergence point of the 3 independent reactions gives $P = 8.14$ kilobars and $T = 685°C$. With staurolite and water included, 4 linearly independent reactions were calculated and they converge at $P = 8.2 \pm 1$ kilobars and $T = 685 \pm 50°C$. This result is identical to the anhydrous assemblage when the activity of water in the fluid is 0.83. The results using the INVEQ program for the anhydrous assemblage gives $P = 8.1 \pm 1$ kilobars and $T = 684 \pm 50°C$ (Murphy 1999, 2001).

On the *P–T* diagram (*see* Figure 39) both of the samples described above plot to the right of the melting curve for muscovite and quartz when the activity of water is 1. When the activity of water is changed to 0.83 to 0.87, the melting curve shifts to higher temperatures. The new position of the melting curve has not been determined but field and petrological constraints indicate it must lie between the "transitional zone" and Grenville Province samples as illustrated in Figure 39. This might explain why partial melting (migmatites) is only observed in the samples located south of the Grenville Front boundary fault.

Temperature conditions for other metapelites across the Grenville Front boundary fault in the Timmins Creek area were estimated using garnet-biotite thermometry (*see* Table 8). Assuming a pressure near 7.3 kilobars (as obtained using TWEEQU and INVEQ for sample 96RME-3112) temperatures average 640°C (samples 96RME-3005, 96RME-3006, *see* Table 8). South of the Grenville Front boundary fault, the same approach for $P = 8.1$ kilobars yields $T = 715°C$. The 20 to 30°C difference between these estimates and those generated by TWEEQU and INVEQ are within the ±50°C error (*see* Table 8) inherent in such calculations. Nevertheless, field and petrological data previously presented by Murphy (1999, 2001) indicate that the mineral assemblages south of the Grenville Front boundary fault crystallized at higher temperatures.

For mafic units, temperature estimates are based upon the amphibole-plagioclase thermometer calculated by Holland and Blundy (1994) (*see* Table 8 and 9). These temperature estimates are determined with the assumption that $P = 7.3$ kilobars north of the Grenville Front boundary fault (as calculated by TWEEQU and INVEQ, sample 96RME-3112) and $P = 8.1$ kilobars south of the Grenville Front boundary fault (using TWEEQU and INVEQ, sample 96RME-0242). From north to south, temperatures increase from 630 to 725°C. These data are consistent with other thermobarometry and the geological and petrological data reported by Murphy (1999, 2001). Low temperatures obtained from one sample ($T = 509$ to 542°C, sample 96RME-3147, *see* Table 8) likely reflects the effects of retrograde metamorphism along shear zones present in the area.

Temperature estimates for felsic rocks are also presented in Table 8. The garnet-biotite thermometer (Hodges and Spear 1982) was applied to samples 96RME-3008 and 96RME-3022, where $T = 685°C$ and $T = 720°C$ respectively. Using the hornblende-plagioclase thermometer (Holland and Blundy 1994), sample 96RME-0124 gives $T = 640°C$.

COOLING HISTORY OF THE TIMMINS CREEK AREA

The thermobarometric data in conjunction with the U/Pb geochronological data listed in Table 6 permit construction of a temperature-time history or cooling curve for the Timmins Creek area (Table 10; Figure 40). Thermobarometric results yield peak metamorphic conditions at 8.2 kilobars and 725°C, which are above the closure temperature for the U/Pb system in zircon. It is unknown how long the rocks were at or near peak metamorphic conditions. However, the lack of any petrological evidence for earlier metamorphism and the limited isotopic evidence for older events in zircon and titanite (*see* Table 6) suggests that peak metamorphic conditions may have existed over a protracted length of time (tens of millions of years). Once the Timmins Creek area was exhumed, however, cooling occurred rapidly (15°C/Ma) for the first 10 to 15 million years (*see* Figure 40), moderating (4.5°C/Ma) through the temperature interval 550 to 400°C. The average cooling rate for the interval 990 to 940 Ma is estimated at 5.5°C/Ma (*see* Table 10).

For comparative purposes, Table 10 also lists cooling history data from the Grenville Front tectonic zone in the Killarney and Temagami areas of Ontario. Data from the Killarney area (*see* Table 10) show a rapid cooling through the temperature interval 650 to 350°C over 25 Ma at a cooling rate of 12°C/Ma and 5.8°C/Ma over 60 Ma for the temperature interval 650 to 300°C. These results are comparable to those obtained in this study. A similar cooling history is present in the Temagami area (*see* Table 10), namely, a cooling rate of 7°C/Ma over a temperature range 650 to 300°C (*see* Table 10).

Table 10. Cooling history estimates for the Grenville Front in the Sudbury area.

TIMMINS CREEK (Corfu and Easton 2000)			
Age	**Closure Temperature**	**Mineral/Method**	**Comments**
995+/-3 Ma	>700°C	Zircon U/Pb	C5, C2-C1 zircon range 989-995+/-3 Ma
987+/-3 Ma	650°C	Monazite U/Pb	C6 concordant monazite $^{207}Pb/^{206}Pb$ age, C5,C6 monazite range from 989 to 977 Ma
987+/-9 Ma	550°C	Titanite U/Pb	C3 concordant, $^{207}Pb/^{206}Pb$
974+/-4 Ma	430°C	Rutile U/Pb	C5, C6, $^{207}Pb/^{206}Pb$, most concordant grains
949+/-10 Ma	400°C	Apatite U/Pb	C6, $^{206}Pb/^{238}U$
Cooling 700-400°C in 46 Ma = 6.52°C/m.y.			
Cooling 700-400°C in 59 Ma = 5.10°C/m.y.		Max. zircon to minimum apatite (slowest cooling)	
Cooling 700-400°C in 33 Ma = 9.10°C/m.y.		Min zircon to max. apatite (fastest cooling)	
KILLARNEY AREA (Haggart et al. 1993, Krogh 1994)			
977+/-12 Ma	>700°C	Zircon U/Pb	
988+/-2 Ma	650°C	Monazite U/Pb	
978+/-13 Ma	550°C	Titanite U/Pb	
975-1000 Ma	340°C	K-feldspar Ar/Ar	
930+/-5 Ma	320°C	Muscovite Ar/Ar	
970-1240 Ma	300°C	Biotite Ar/Ar & K/Ar	Excess Ar
Cooling 650-350°C in 25 Ma = 12.0°C/m.y; 650-300°C in 60 Ma = 5.8°C/m.y.			
TEMAGAMI AREA (Smith et al. 1994, Krogh 1994, Krogh & Davis 1970)			
988+/-5 Ma	>700°C	Zircon U/Pb	
988+/-5 Ma	650°C	Monazite U/Pb	
991+/-2 Ma	550°C	Titanite U/Pb	
977+/-4 Ma	500°C	Hornblende Ar/Ar	
938+/-4 Ma	320°C	Muscovite Ar/Ar	
954+/-4 Ma (max).	300°C	Biotite Ar/Ar & K/Ar	Excess Ar, range 1260-1008 Ma
940 Ma	300°C	Biotite Rb/Sr	
842 Ma	?°C	Apatite Rb/Sr	
Cooling 650-300°C in 50 Ma = 7.0°C/m.y.			

Abbreviations: Ar/Ar = Ar^{39}/Ar^{40}, K/Ar = K^{39}/Ar^{40}; Rb/Sr = Rb^{86}/Sr^{87}; U/Pb = U^{238}/Pb^{206}; 238; m.y. = million years.

Cooling rates for the Grenville Orogen calculated by Mezger et al. (1991) for the Adirondack Highlands, New York, USA are much lower than those obtained in the Grenville Front tectonic zone of Ontario. In the Adirondack Highlands, initial cooling from the inferred peak temperature of 750°C was 4°C/Ma, decreasing to 1°C/Ma in the latter stages of cooling. Cosca, Sutter and Essene (1991) reported similar slow cooling rates of 2 to 4°C/Ma for the Central Metasedimentary Belt and the Central Gneiss Belt of the Grenville Orogen in Ontario.

P–T–t PATH FOR THE TIMMINS CREEK AREA

There are several techniques to evaluate the pressure-temperature-time (*P–T–t*) paths followed by rocks during a metamorphic event. These are 1) mineral zoning studies (Spear and Selverstone 1983); 2) calculation of pressure and temperature from retrograde mineral assemblages (Jamieson 1986); 3) order–disorder kinetics (Anovitz et al. 1988); 4) $^{40}Ar/^{39}Ar$ systematics (Cosca, Essene and Sutter 1987); and 5) geophysical models (England and Thompson 1984; Thompson and England 1984).

Murphy (1999) obtained analyses of 'core' and 'rim' compositions of individual minerals in her study of the Timmins Creek area. In most cases, 'core and rim' analyses on garnet, biotite, hornblende and plagioclase lacked significant zoning (Murphy 1999), which makes it difficult to apply either technique 1 or 2. However, *P–T* data from different samples can be linked into *P–T–t* paths if the samples share a common metamorphic history; if each sample can be placed in its correct relative position in the metamorphic sequence; and if the samples are spaced closely enough that major differences in *P–T–t* history between outcrops are unlikely (Jamieson, Culshaw and Corrigan 1995). Samples from the Timmins Creek area meet these criteria and the *P–T–t* path proposed by Murphy (1999) is illustrated in Figure 41. Murphy (1999, 2001) suggested that the clockwise *P–T–t* path shown in Figure 41 resulted from loading of crust due to thrusting, with subsequent isobaric heating to near peak temperatures. Subsequently, a period of uplift and cooling with a monotonic decrease in both pressure and temperature occurred. This scenario is similar to the model of "suddenly doubled crust" suggested by England and Thompson (1984) to explain the formation of medium to high grade metamorphic rocks.

Bethune (1993) estimated peak pressures and temperatures in the order of 8 kilobars and 680°C for metamorphosed Sudbury diabase dikes from the Grenville Front tectonic zone, near Tyson Lake in the Killarney area. Bethune (1993) determined a *P–T–t* path suggesting near isothermal decompression (680 to 700°C) over the range from 8 to 5 kilobars. These results are consistent with the data presented above.

Geophysics

AIRBORNE MAGNETIC DATA

The airborne total magnetic field data (Ontario Geological Survey 1991a) show only limited correlation with the mapped surface geology, in large part reflecting the relatively coarse (800 m) line spacing of the regional survey even when plotted at 1:20 000 scale. In particular, the southwest and northeast segments of the Grenville Front are not particularly well defined. The Upper Wanapitei River fault shows up weakly, largely because it separates a region dominated by moderate to high magnetic signature to the west from a magnetically low area to the east. In contrast to the weak magnetic signature of these first-order structures, northwest-trending faults in the western part of Street Township, such as the Norduna, Leblanc Creek and Airport faults are associated with magnetic highs elongated along the trace of these faults. These magnetic highs are associated with the presence of Sudbury diabase dikes along the fault

traces, as well as with areas of albitization along these faults. In particular, the McVittie occurrence (Occurrence 3, Map P.3427, back pocket) has an associated magnetic high. At present, it is not known why the areas of albitization are associated with magnetic highs, although it is possible that disseminated magnetite within these zones may be responsible for the magnetic response. It is expected that high resolution surveys would be useful in defining the traces of these faults in poorly exposed areas and in identifying areas of albitization.

The only geological unit that has a distinctive magnetic signature are the granitoid rocks of unit 9, which are characterized by a moderate to high magnetic response. These rocks occur both in the Timmins Creek area and in the southeast corner of Street Township.

Maps of the first vertical derivative of the magnetic field (Ontario Geological Survey 1991b), plotted at 1:20 000-scale, reflect the broad observations noted above for the total magnetic field, with the following exceptions: first, the change in magnetic character across the Upper Wanapitei River is less pronounced; second the highs associated with the northwest-trending faults in west Street Township are more clearly defined.

GRAVITY DATA

The bouguer gravity data (Ontario Geological Survey 1991c) show a large regional gravity high underlying an area of roughly 400 km^2 that extends along and south of the Grenville Front from Street Township eastward to River Valley. This gravity high corresponds to an area underlain mainly by Neoarchean orthogneiss and paragneiss and mafic rocks of the circa 2475 Ma River Valley intrusion. The westward extent of this gravity high terminates at the Upper Wanapitei River fault.

Economic Geology

Kindle (1933) reported on the earliest mineral exploration activities in the area. Table 11, a summary of the mineral exploration history of Street Township, was compiled from reports filed for assessment work credits (Assessment Files, Resident Geologist's office, Sudbury), Geological Data Inventory Folio 340 (Ontario Geological Survey 1987) and Gates (1991). Readers are referred to these sources for detailed accounts of previous exploration work.

Exploration has focussed mainly on the parts of the township underlain by the Southern Province, specifically, along the western border of the map area with Falconbridge Township; along the Wanapitei River; and between the Grenville Front and the northern border of the township with Scadding Township. Gold and copper have been the most actively sought economic commodities in the map area, and the three main exploration areas all host mineralization associated with albite alteration zones associated with major faults (Meyer et al. 1990; Gates 1991; Easton et al. 1996). In addition, exploration for "offset-style" nickel-copper sulphide mineralization associated with the Sudbury Structure has occurred along the border between Falconbridge and Street Township.

Exploration in the Grenville Province has been limited to examination of a gold occurrence located a few hundred metres south of the Grenville Front. In the early 1990s, garnet-rich gneisses within the Grenville Province were subjected to detailed examination (*see* Table 11), as discussed in greater detail below. The following section reports on data obtained by the field party during the 1996 field season and offers observations and interpretations of the geology in and around the various occurrences shown on Map P.3427 (back pocket).

Table 11. Summary of mineral exploration work in Street Township.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Acrodat Limited	Falconbridge, western Street, Scadding townships	1984	Various	Acromagnetic, EM and VLF-EM surveys.			Falconbridge-37-001A.
Acrodat Limited	Area 1 – 10 claim block east of Lambert rapids Area 2 – 16 claim block west-central Street Twp.	1985	Various	Acromagnetic, EM and VLF-EM surveys.		Goldteck Mines and Midway Energy and Resources follow-up work on Area 2 results.	Street SP-001.
BP Resources Canada Limited	Street Twp. along the Wanapitei River	1987	Various	Acromagnetic, EM and VLF-EM surveys.			Falconbridge-SP-003.
Bradley, D. (occurrence 1)	6 claim group in area of Potvin-Boulanger occurrences	1989, 1991	Au	Prospecting, assay sampling.	Best assays range from 0.04 to 0.09 g/t Au, one sample site analyzed 36 and 58 ppb Pt.		Street-SP-06, see also description in Kindle (1933), OP-89-70, OP91-514.
Brown, P. and Graham, R.	11 claims north of Timmins Creek	1983	Unknown	Ground magnetic and VLF-EM surveys.		Work on a mainly covered area.	Street-015.
Canadian Nickel Company Limited	Street Twp. on border with Falconbridge Twp.	1981	Various	Acromagnetic, EM and gamma-ray surveys.		Mainly in Falconbridge Twp.	Falconbridge-032.
Ecosource Garnet Inc. (occurrence 2b)	Central Street Twp., Central Zone	1999	Garnet	Diamond drilling	9 diamond-drill holes	Resource assessment, minimum 100 000 tonnes garnet	Street-SP-016
Emerald Isle Resources Inc., Stralak Resources Inc. (occurrence 2b, 2c)	Central Street Twp., North Zone, Central Zone	1993	Garnet	Stripping, diamond drilling.	All diamond-drill holes in zone 2 intersected 6-14 wide zone of garnet mineralization.		Street-SP-015, Street-SP-014, OMIP File#95-053.
Emerald Isle Resources Inc., Stralak Resources Inc.; Jarvis Resources (occurrence 2a)	Central Street Twp., South Zone	1991, 1993	Garnet	Stripping, access road construction, diamond drilling, bulk sampling, industrial mineral testing.			Street-SP-012, Street-SP-011, Street-SP-010, Street-SP-009-#2, Street-SP-008.
Foisey, A.	Southwest corner	1958	Unknown	Diamond drilling.	1 diamond-drill hole, no results reported.		Street-011-A1.
Goldteck Mines	8 claim block in west-central Street Twp., due north of Midway Mines and Energy claims	1987-1989	Au, Cu-Ni; exploring for offset mineralization	Geological mapping, soil geochemistry, ground magnetic and VLF-EM surveys.			Street-SP-007, Street-SP-005, Street-SP-018.
Gulf Minerals (drill hole A)	Timmins Creek area	1975-1976	U, Th	Diamond drilling.	9 diamond-drill holes.	Watt-McLean followed up on diamond-drill results.	Street-010-B1 (DD11).
International Freegold Inc.	Street metagabbro, southwest Street Twp.	1999-2000	Ni-Cu-PGE	Prospecting, ground VLF-EM and magnetics, assay data	Best assays, 244 ppb Pt, 543 ppb Pd, 344 ppb Au, 0.25% Cu, 0.10% Ni		Street-SP-021
Jamestown Explorations Incorporated	northeast of Boulanger–Potvin occurrence	1974	Unknown	No data on exploration program.			Street-011-B1.
Jerome, A.E. (occurrence 2a)	Central Street Twp.	1993	Garnet	Trenching, stripping			Street-SP-017.

Table 11. Summary of mineral exploration work in Street Township — continued.

Company or Individual	Location	Year of Work	Commodity	Work	Best Results	Comments	RGO File Number or Other Reference
Midway Mines and Energy (occurrence 7, drill hole B)	6 claim block in west-central Street Twp.	1987-1989	Mineralization at contact of Nipissing gabbro and sediments, Au, Ni-Cu	Diamond drilling, geological mapping, soil geochemistry, ground magnetic and VLF-EM surveys.	Best chip sample assays were 465, 566, 756 ppb Au; 3 holes drilled to test geophysical anomalies, 1 diamond-drill hole contained 0.04-0.08 g/t Au.		Street-SP-002, Street-SP-003, Street-SP-004, Street-SP-018.
McVittie, G. (occurrence 3)	West shore, Wanapitei River	Circa 1930	Au, Cu	Trenching, prospecting			Kindle (1933), Gates (1991)
New Arcadia Explorations Limited	Along Grenville Front, southwest Street Twp.	1984	Au, base metals	Geological mapping.			Dryden-020-A1.
Nickel Valley Copper Mines	West-central Street Twp.	1956-1957	Ni-Cu	Airborne EM, ground magnetic, geology.		Mostly in Falconbridge Twp.	Awrey-010-B1.
Nipiron Mines Limited	6 claim block, southwest corner, Street Twp.	1958		Diamond drilling.	5 diamond-drill holes.		Street-010-A1 (DD10).
Prosco Mines Limited	Southwest corner of Street Twp.	1957	U, Cu	Prospecting.		Few details in file.	Falconbridge-033-B1.
Racicot, Frank	East Bull Lake intrusion, SW Street Twp.	2000	Ni-Cu-PGE	Prospecting, ground magnetics			Street-SP-020
Sunbeam Exploration Limited	West-central Street Twp.	1956-1957	Ni-Cu	Prospecting.		Mostly in Falconbridge Twp., few details in file.	Davis-039-1.
St. Genevieve Resources Limited (occurrence 8)	Northeast corner, Street Twp.	1987	Au, Cu	Prospecting, geological mapping, ground magnetic and VLF-EM surveys.		Mostly in Scadding, follow-up on Au in humus anomalies in Scadding Twp. reported by Ateba Mines in 1981.	Scadding-SP-02; Ateba Mines data in Scadding-040, -052.
Watt-McLean (drill hole C)	Northeast of Jackson Lake	1982-1983	Au, base metals	Geological mapping, diamond drilling, assay results.	6 diamond-drill holes, py, po with asp & sp in hangingwall, anomalous Au, old pit in Timmins Creek area assayed 10.9 g/t Au.		Street-016, Street-013, Street-012 (DD12).
Watt-McLean	Along Grenville Front throughout township	1984	Au, base metals	Geological mapping.			Street-014.
WMC International Limited	Southeast corner and east boundary of Street Twp.	1994-1996	Ni-Cu-PGM	Geological mapping, soil geochemistry aeromagnetic survey, rock assays.	Most assay work on samples from Emerald Isle Resources garnet property.	Survey area stretched from Street Twp to River Valley, only minor work on claims in Street Twp.	
W.R.3 (occurrence 8).	Timmins Creek area.	1992	Au	Prospecting, soil sampling.	350 ppb Au, 11 800 ppb Au in arsenopyrite-rich sample	Examined pit found in 1975 by Gulf Minerals, Watt McLean reported a sample from the pit assayed 10.9 g/t Au	Scadding SP-021, OP92-186, see also Kindle (1933), Gates (1991).

Abbreviations: EM = electromagnetic survey; g/t = grams per tonne; Twp. = township; VLF-EM = very low frequency electromagnetic survey.

DESCRIPTION OF PROPERTIES

Boulanger–Potvin (Gold, Copper)

Kindle (1933) described both of these properties which occur east of the Wanaiptei River, south of Timmins Creek. Field party personnel were unable to locate the Boulanger vein or pit due to thick overgrowth. Kindle (1933) reported 3 pits sunk on quartz veins on the Potvin property. Field party personnel located only 1 pit in this area, at UTM 528104E, 5160265N. The 0.5 by 0.5 by 0.5 m pit is sunk on a 30 to 60 cm wide quartz vein in Bruce Formation conglomerate. Sulphide minerals in the vein consist of pyrite, pyrrhotite and arsenopyrite. An assay sample from this pit (96RME-0366, Table 12) yielded 316 ppm Cu, 229 ppm As and 316 ppm Ni. This vein, and the others on the property, occurs near the trace of the south branch of the Airport fault that juxtaposes Bruce Formation conglomerate to the north against Serpent Formation meta-arenite to the south. Given the proximity to the fault, additional exploration for albite-associated gold and copper mineralization is warranted on the old Potvin occurrence.

Table 12. Assay results from various gossan zones, quartz veins and occurrences in Street Township from samples collected by field party personnel.

Sample Number	Easting	Northing	Field Rock Name	Au ppb (2)	As ppm (6)*	Cu ppm (5)*	Cr Ppm (5)*	Ni ppm (5)*	Pb ppm (7)*	Zn ppm (2)*	Na_2O wt %
96RME-0065A	527035	5154065	Gossan in unit 2	N.D.	N.A.	150	N.A.	13	10	67	N.A.
96RME-0065B	527035	5154065	Gossan in unit 2	N.D.	N.A.	72	N.A.	13	8	56	N.A.
96RME-0065C	527035	5154065	Gossan in unit 2	N.D.	N.A.	173	N.A.	54	9	131	N.A.
96RME-0066	527015	5154105	Rusty schist	N.D.	N.A.	11	N.A.	<5	8	18	N.A.
96RME-0071	527100	5154480	Gossan in unit 2	N.D.	N.A.	<5	N.A.	6	16	48	N.A.
96RME-0096	531330	5162570	Alteration zone at Bruce/Mississagi Fm. contact	N.D.	N.A.	<5	N.A.	9	<7	<2	N.A.
96RME-0103	529580	5158020	Alteration in unit 1	N.D.	N.A.	158	N.A.	62	<7	95	N.A.
96RME-0113	529870	5158650	Quartz vein	N.D.	N.A.	15	N.A.	5	<7	5	N.A.
96RME-0118	530065	5158020	White vein in road	N.D.	N.A.	136	N.A.	18	28	18	N.A.
96RME-0195A	527280	5154500	Gossan in unit 2	N.D.	N.A.	43	N.A.	12	30	82	N.A.
96RME-0195B	527280	5154500	Gossan in unit 2	N.D.	N.A.	47	N.A.	12	23	61	N.A.
96RME-0195C	527280	5154500	Gossan in unit 2	N.D.	N.A.	7	N.A.	6	18	41	N.A.
96RME-0221	528300	5162700	Quartz vein, Bruce Fm.	N.D.	12	6	N.A.	106	<7	5	0.06
96RME-0223	528700	5162090	Albitite, Bruce Fm.	N.D.	<6	23	N.A.	34	<7	25	4.29
96RME-0243	528500	5161400	Albitite, Bruce Fm.	N.D.	<100	<100	245	<40	<40	<50	3.92
W.R.3											
96RME-0237	531590	5161620	Quartz vein with asp	N.D.	>500	<5	N.A.	<5	<7	<2	N.A.
89BIG-0032	531590	5161620		950	N.A.	20	N.A.	<5	<10	10	7.84
Boulanger–Potvin											
96RME-0366	528030	5160250	Sulphide-bearing vein	N.D.	229	316	326	316	<40	<50	<0.01
McVittie											
96RME-0371A	525885	5158385	Quartz vein	N.D.	153	1479	298	41	<40	<50	2.30
96RME-0371B	525885	5158385	Rusty quartzite	N.D.	165	<100	200	<40	<40	<50	6.11
96RME-0371C	525885	5158385	Sulphide-rich zone	700	771	3196	323	<40	<40	<50	1.97
88BIG-0070	525885	5158385	Near 96RME-0371C	85	N.A.	8400	36	26	<10	18	4.69
88BIG-0071	525885	5158385		25	N.A.	455	117	15	<10	<5	6.09
Occurrence #2											
96RME-0440A	524840	5155890	Hematite-stained quartzite	N.D.	<100	<100	355	<40	<40	<50	2.51
96RME-0440B	524840	5155890	Sulphide-bearing quartzite	Trace	136	<100	264	<40	<40	<50	10.01

Abbreviations: N.D. = not detected, N.A. = not analyzed. 88BIG- and 89BIG samples from Gates (1991).
* number in brackets indicates detection limit for the respective element.

Ecosource Garnet Inc. (Garnet, Kyanite, Vermiculite)

The Ecosource Garnet Inc. property can be accessed from the Kukagami Lake Road, using a 3 km long gravel road that extends subparallel to the Grenville Front and the axial trace of a regional synform (Figure 42). Three separate test quarries are located along the access road. The first quarry is located about 1.5 km from the Kukagami Lake Road and consists mainly of garnet-rich quartzofeldspathic gneiss (*see* Figure 42). The second quarry (Photo 25) is located about 2.5 km northeast of the Kukagami Lake Road and contains garnet-rich quartzofeldspathic gneiss (Photo 28), garnet-gedrite rock with golf ball-size garnets (Photos 26 and 27) and kyanite-garnet gneiss. The third quarry is located at the end of the road and consists of garnet-rich quartzofeldspathic gneiss and muscovite-garnet paragneiss. These quarries will be referred to as the South, Central and North zones, respectively (*see* Figure 42).

The early exploration history of this property is not well documented in the literature or the assessment files. Initial work on the property in 1993 by Emerald Isle Resources Inc. and Stralak Resources Inc. focussed on the South Zone, and included construction of an access road, overburden stripping and sampling, detailed geological mapping of a 250 by 500 m area and diamond drilling. Prospecting by Albert Jerome, between 1993 and 1995, outlined several additional garnet-rich horizons north of the South Zone, which were stripped, mapped and diamond drilled in 1995. By 1996, Ecosource Garnet Inc. had acquired the property and several bulk samples were removed for mill tests prior to the 1996 field season. At that time, Ecosource Garnet Inc. was focussing on marketing the garnet for use in water-jet cutting (Company staff, personal communication, 1996). In 1999, a resource assessment by Ecosource Garnet Inc., focussing on the Central Zone, estimated a resource of 100 000 tonnes of garnet (Brown 2000). Exploration for vermiculite was being conducted in the vicinity of the South Zone in the summer of 1999. The highest vermicullite potential was associated with altered muscovite-rich paragneiss (unit 3) located in topographic lows along east- and northeast-trending lineaments.

In 1998, the Ministry of Northern Development and Mines commissioned a test of 5 garnet localities in the northern Grenville Province in Ontario (Grammatikoploulus et al. 1999). Three samples were directly relevant to this study: 1 sample came from Street Township and 2 other samples came from Janes and Dana townships, likely from the eastward continuation of the same tectonostratigraphic horizon found in Street Township. The Street Township sample was collected from garnet-rich quartzofeldspathic gneiss from the North Zone (NTS 41I/10, UTM 530220E, 5159050N) and was representative of the exposed resource. The validity of this sampling rationale is justified if one compares the chemistry of the Street Township head sample, presented herein, with the whole rock geochemistry presented in Easton (1996) (*see* Table 13). The head sample and sample 95RME-0137 (North Zone), sample 95RME-0136 (Central Zone), and sample 95RME-0150 (South Zone) are all chemically similar. Variation in chemistry is due to minor differences in garnet content. Unpublished mineral chemistry data, collected by Easton from the garnet-rich quartzofeldspathic gneiss, the kyanite-garnet gneiss and the garnet-gedrite rocks, only show minor chemical variations between the 3 rock types. The composition of garnets from all 3 rock types is similar to that reported herein for the Street Township sample.

Grammatikopoulus et al. (1999) provided the following quality data for the Street Township garnets. Grain size in the head sample ranged from 0.1 mm to 5 cm with a quality index of 5/10 where 0 represents inclusion and alteration free grains (excellent quality) with greater than 95% of the grains having inclusions and alteration. Compositional zoning in the Street Township garnets is minimal (<2.5 mole%) with an overall composition of $Alm_{72.6-75.1}Prp_{9.1-11.5}Grs_{12.3-14.4}$. Whole rock chemical data on the head sample are provided in Table 13. Barium content, in the Street Township sample, is related to the amount of mica in the sample and is estimated at 10 to 15 volume percent for the Street Township sample. Grammatikopoulous et al. (1999) also tested garnet recovery following an iterative cycle of crushing and magnetic separation. Results showed that although garnet recoveries were generally very high, the

concentrate grades were generally poor. Grammatikopoulus et al. (1999) attributed this to the following factors: 1) the degree of liberation was insufficient particularly at the coarser sizes; 2) overlapping magnetic susceptibilities of garnet and gangue components reduced the effectiveness of magnetic separation; 3) the high proportion of deleterious gangue impeded efficient magnetic separation; and 4) the absence of a suitable pre-concentration stage to eliminate lighter silicates. A test using heavy liquid separation, prior to magnetic separation, improved concentrate grade with no loss in recovery.

A brief comment is warranted with respect to the possible protolith of the Street and Dana Township samples as this topic has implications for exploration for additional resources. Lumbers (1973) regarded his unit 18 (muscovitic and quartzose gneiss) as being wholly of metasedimentary origin. However, the

Table 13. Chemistry of garnet-bearing felsic gneisses from Street and Dana Townships.

Sample No.	95RME-0136	95RME-0137	Head sample, Street	95RME-0150	Head sample, Dana
Easting	530150	530252	530253	525000	563070
Northing	5158362	5159057	5159057	5151800	5168225
Wt. %					
SiO2	56.26	51.73	56.10	51.80	52.90
TiO2	1.01	0.96	0.92	1.38	0.78
Al2O3	16.77	17.53	14.30	19.06	16.70
Fe2O3	16.10	23.86	22.10	21.31	19.80
MnO	0.21	0.30	0.26	0.20	0.16
MgO	3.11	1.31	2.61	1.79	5.89
CaO	2.28	2.18	2.75	0.98	1.13
Na2O	2.58	0.03	0.25	0.13	0.98
K2O	1.37	1.82	1.91	2.26	2.25
P2O5	0.18	0.04	0.16	0.10	0.25
H2O-	0.12	0.14		0.16	
CO2	0.09	0.15		0.09	
S	0.08	1.09		0.16	
LOI	0.01	0.02	0.59	0.22	0.22
Total	99.16	99.68	101.95	97.85	101.06
CIA	73.20	81.88	74.44	85.32	79.30
Mg #	27.66	9.81	18.96	14.26	37.07
ppm					
Cr	145	186	300	99	300
Ni	66	97		67	
Co	44	57		49	
Sc	27	28		33	
V	196	188	400	305	200
Cu	114	228		79	
Zn	110	96		67	
Rb	54	64	96	69	42
Ba	809	894	420	1595	451
Sr	56	12	11	12	57
Nb	12	9	8	21	13
Zr	216	183	169	467	208
Y	49	53	35	112	18
Zr/Y	4.4	3.5	4.8	4.2	11.6
La	30.12	27.76		289.95	
Ce	62.65	56.78		500.02	
Pr	7.97	7.11		77.22	
Nd	30.76	27.90		291.88	
Sm	6.85	6.63		49.65	
Eu	1.63	1.60		5.01	
Gd	7.40	8.47		33.02	
Tb	1.28	1.47		3.92	
Dy	8.09	9.39		17.20	
Ho	1.68	1.84		3.50	
Er	4.95	5.18		10.27	
Tm	0.73	0.73		1.52	
Yb	4.76	4.68		10.30	
Lu	0.75	0.69		1.56	

Abbreviations: CIA = Chemical Index of Alteration $(Al_2O_3/(Al_2O_3 + (CaO\text{-}CO_2) + Na_20 + K_20))*100$; Mg# = magnesium number.

geochemistry of the Street and Dana township samples, reported herein (*see* Appendix 1), have low Al_2O_3, Na_2O and Sr contents and high Fe_2O_3 contents, all features atypical of pelitic rocks (*see* Table 13). In the case of the Street Township rocks, this unusual chemistry led Easton (1996) to speculate that the garnet-rich quartzofeldspathic gneisses were derived from hydrothermally altered felsic and intermediate volcanic rocks interlayered with a few sedimentary horizons; whereas the associated garnet amphibolites were derived from mafic volcanic or volcaniclastic rocks. Subsequent regional metamorphism associated with the Grenville orogeny led to the development of the large garnet porphyroblasts now present in these rocks. If this is indeed the case, then one might expect the resultant original alteration pattern to have been irregular, and of varied intensity. This may explain why the garnet-rich zones are present as discontinuous zones, of varied mineralogy, rather than be more homogeneous in composition. This, combined with structural transposition and fold repetition, may also explain why this zone occurs in a narrow horizon near the Grenville Front yet can be traced for almost 50 km along strike from Wahnipitae (Grant et al. 1962) to Dana Township.

McVittie (Gold, Copper)

As noted by Gates (1991), this occurrence is incorrectly located in the Street Township GDIF (Ontario Geological Survey 1987), on the Sudbury geological compilation map (Dressler 1984a) and the Mineral Deposit Inventory (MDI) database. The occurrence was initially staked in 1931 and Kindle (1933) described the property and included a sketch map. Gates (1991) revisited the property and provided an updated sketch map and description and history of the property. The showing is located on a low hill bounded by glacial drift. It occurs in a meta-arenite that is variably albitized, brecciated and cut by quartz veins. The showing is transected by a 150 m long trench that extendsfrom the Wanapitei River along a 280° trend. The trench is straight, roughly 2 to 3 m wide, 1.5 to 2 m deep and remarkably free of debris.

The host rocks are a meta-arenite and associated metawacke. Assignment to a particular formation is equivocal given the altered and fractured nature of the rock. Gates (1991) suggested that the rocks may be part of the Mississagi Formation, however, based on regional stratigraphy, the rocks may be part of the Serpent Formation near the Serpent-Gowganda formation contact. The meta-arenite is shattered and filled by narrow, grey quartz veinlets that contain fine-grained pyrite and minor chalcopyrite. The veinlets generally strike 020°. Younger barren veins, striking 280°, cut the mineralized veins. The best sulphide mineralization occurs in the east part of the trench and decreases to the north and west. Assay data from 5 samples collected at the occurrence, 2 of which are from Gates (1991), are reported in Table 12. Copper values range from 100 to 8400 ppm; gold values range from below detection limits to 700 ppb. High arsenic values, in some of the samples, suggest the presence of arsenopyrite. The best gold value (700 ppb) came from the sample with the highest As value (771 ppm). If correlative with the Serpent Formation, then 2 of the 5 samples show sodium enrichment (>6.0 wt.% Na_2O compared to typical Serpent Formation samples which contain about 4.75 wt.% Na_2O). If correlative with the Mississagi Formation then the samples show even greater sodium enrichment.

Page (Garnet)

This occurrence is located in Loughrin Township, roughly 200 m east of the Street Township boundary. There is some confusion over the exact location of the Page garnet occurrence. Vos, Smith and Stevenato (1981) describe a kyanite-bearing garnet property in Lot 14 (N1/2), Concession III of Loughrin Township which is mineralogically consistent with the pit shown on Map P.3427 (back pocket). However, an assessment file report by R.V. Stewart in 1991 describes a garnet occurrence on Lot 14 (S1/2), Concession III of Loughrin Township, which is refered to as the Page occurrence. The location shown on

the Geological Data Inventory Folio (Ontario Geological Survey 1985) and on Lumbers (1973) is the southern location. It is possible that there are two separate garnet occurrences with the northern occurrence being kyanite-bearing.

The kyanite-bearing occurrence consists of a 3 m x 2 m x 1 m pit blasted into an outcrop of kyanite-garnet-biotite gneiss. Kyanite occurs both in the rock and in crosscutting veins. Garnet ranges in size from 2 mm to 3 cm in diameter. The occurrence is surrounded to the west and south by melanoamphibolite of the East Bull Lake intrusive suite. It is possible that the gneiss hosting the occurrence is in a large block engulfed by the mafic intrusive rocks.

Potvin (Pyrrhotite, Pyrite)

As described by Kindle (1933), this occurrence is located just south of the railway bridge on the east bank of the Wanapitei River. The occurrence was not located duting this project probably due to slumping along the rail bed and overgrowth. Kindle (1933) describes the presence of sparse pyrite and pyrrhotite in quartz stringers at this occurrence. Exposures of meta-arenite, in the Wanapitei River near this occurrence, contain quartz stringers but no noticeable sulphide minerals. This locality occurs near the trace of the Airport fault and the sulphide mineralization and quartz veining may be related to the fault.

Street Occurrence #1 (Gold, Copper, Nickel)

Four pits were located during this project within a 200 m^2 area just west of the Wanapitei River in the southwest part of the map area. The pits are hosted within Nipissing gabbro and were excavated sometime in the last 25 years. No assessment work is on file for these pits in either the Sudbury Resident Geologist's office or in ERLIS. A description of each pit is given in Table 14. The presence of high gold, copper and nickel values in one sample collected during this project (sample 96RME-0439, Table 15) suggests that this part of the Nipissing gabbro should be explored for gold, copper-nickel sulphide mineralization, and PGE mineralization.

Table 14. Description of pits hosted in Nipissing gabbro at the Street occurrence #1.

Easting	Northing	Dimension	Comment
524805	5155045	1m x 1m x 1m	10-15 cm wide quartz vein, with pyrrhotite and pyrite filling vugs in quartz and altered gabbro.
524700	5155230	10m x 20m x 3m	Pyrrhotite, pyrite in altered gabbro. Alteration assemblage of siderite, epidote, tremolite, and asbestiform tremolite. Assay sample 96RME-0439, Table 15 contains gold, copper and nickel.
525060	5155290	5m x 3m x 3 m	In altered gabbro, minimal visible sulphide minerals. Midway Energy & Resources reports 565 ppb Au from this location.
525060	5155225	1m x 1m x 1m	In altered gabbro, minimal visible sulphide minerals.

Street Occurrence #2 (Gold, Copper)

Midway Energy and Resources Ltd. reported gold and copper mineralization in altered meta-arenite near the northern contact of the Nipissing gabbro body in the southwest corner of Street Township. This mineralization is located near the trace of a major northwest-striking fault. The host rock is Serpent Formation meta-arenite that has been albitized and hematite-stained. Two samples collected for assay from this site (samples 96RME-0440A, 96RME-0440B; *see* Table 12) contained trace only gold mineralization, however, one sample contained considerable sodium enrichment, consistent with the effects of albitization found in association with major faults in the township.

W.R.3 (Gold, Copper, Arsenopyrite)

The property was originally surveyed in 1890 and is mentioned in a report by Bell (1891). In the Street Township Geological Data Inventory Folio (Ontario Geological Survey 1987), the property is referred to as the Watt-McLean showing. A grab sample containing 0.32 ounce gold per ton was collected from this site (McLean 1983). Gates (1991) provides a history of the property as well as a description. Williams (1992) examined the property in detail, as part of an Ontario Prospectors Assistance Program Grant (OPAP). Pyrite, arsenopyrite and pyrrhotite are hosted in a 10 to 50 cm wide quartz vein trending 070°. The vein is hosted in a migmatitic granite gneiss (unit 9c). Assay results from 2 samples collected from this site are presented in Table 12. The sample collected by Gates (1991) contains 7.84 wt.% Na_2O which suggests that the host granite has been sodium metasomatized. This is consistent with indications of an isotopic disturbance at circa 1700 Ma in similar granitic rocks located roughly 750 m to the northeast (Corfu and Easton 2000). This property is significant because it indicates that gold and copper mineralization associated with sodium alteration occurs within the Grenville Province adjacent to the boundary with the Southern Province.

ASSAY RESULTS

Table 15 lists assay results for chromium, copper, nickel, platinum, palladium and gold obtained from representative samples from all 5 mafic rock groups in Street Township (except for those of the East Bull Lake intrusive suite which are summarized in Table 16). None of the samples listed in Table 15 or 16 contained significant amounts of visible sulphide minerals, consequently, these samples serve mainly to establish background levels for chromium, copper, nickel, platinum and palladium within the various mafic rock units. Of the 5 mafic rock groups present in Street Township only 3 contain metal values above detection limits.

Easton (1998) reported that orthopyroxene hornblendite contains significant chromium (*see* Table 16) hosted mainly in iron chromite and chromium spinel. Orthopyroxene hornblendite and hornblendite associated with the Street metagabbro (*see* Table 16) also host elevated chromium contents, but lower than those found in bodies located marginal to other anorthositic metagabbro bodies in Street Township. Platinum and palladium values for the orthopyroxene hornblendites are near or below detection limits (*see* Table 15 and 16), however, sample 98RME-0050, a gabbroic anorthosite collected within 50 m of a an orthopyroxenite hornblendite pod within the Street metagabbro; and sample 98RME-0056, an anorthositic gabbro containing hornblendite layers also from the Street metagabbro, show enrichment in PGE suggesting a spatial link between the hornblendites and PGE mineralization.

Three of 9 non-migmatitic amphibolite samples contain elevated platinum and palladium values (samples 96RME-0446, 96RME-1056, 96RME-3150; *see* Table 15) ranging from 32 to 51 ppb combined platinum and palladium. Sample 96RME-3150 also contains anomalous copper, which may be a reflection of the higher sulphur content of this sample (i.e., the sample contains chalcopyrite). The anomalous PGE and copper content in the non-migmatitic amphibolite is consistent with the Nipissing gabbro-like geochemical signature of these rocks (this study). It is also consistent with the observation that PGE and copper-nickel-bearing Nipissing sills, within the Southern Province, occur mainly in the Sudbury area (e.g., Fyon et al. 1992; Lightfoot and Naldrett 1996).

Two samples (96RME-0200 and 96RME-0213), spatially associated with the Street metagabbro, contained the highest platinum and palladium values obtained during this project: 49 and 112 ppb combined platinum and palladium (*see* Table 16). Sample 96RME-0200 was collected from a non-migmatitic, melanoamphibolite with a high magnesium number, whereas sample 96RME-0213 was

collected from a gabbroic meta-anorthosite. Additional sampling and mapping of the Street metagabbro was conducted in 1998 to evaluate the significance of these 2 anomalous samples, as reported in Easton (1999) and summarized in Table 16.

Table 15. Assay results from various mafic rock units from Street Township from samples collected during this project.

Sample No.	Easting	Northing	Field Rock Name	Cr	Cu	Ni	Pt	Pd	S	Au
	Zone 17T			ppm (4)*	ppm (5)*	ppm (5)*	ppb(5)*	ppb(10)*	wt %	ppb(3)*
Migmatitic garnet amphibolite and amphibolite (unit 1, 4)										
95RME-0133	530220	5158690	grt-gedrite gneiss	N.A.	N.A.	N.A.	<10	35	N.A.	4
95RME-0142	529650	5157900	Garnetite	N.A.	N.A.	N.A.	<10	20	N.A.	10
96RME-0028	528675	5156195	grt amphibolite	83	100	83	7	14	<0.01	N.A.
96RME-0029	528666	5156267	grt amphibolite	63	81	74	N.D.	N.D.	<0.01	N.A.
96RME-0031	528675	5156195	Amphibolite	36	89	79	N.D.	N.D.	<0.01	N.A.
96RME-0038	528891	5156969	Amphibolite	147	47	100	N.D.	10	<0.01	N.A.
96RME-0063	527000	5154020	grt amphibolite	37	72	95	8	N.D.	0.01	N.A.
96RME-0064	527000	5154020	grt biotite gneiss	16	100	20	N.D.	N.D.	0.02	N.D.
96RME-0107	529620	5158203	grt amphibolite	18	80	45	6	N.D.	<0.01	N.A.
96RME-0185	527560	5154760	Garnetite	71	58	53	N.D.	N.D.	0.07	N.D.
96RME-0450	532590	5162410	Amphibolite	140	88	64	N.D.	N.D.	0.08	N.A.
96RME-0456	527490	5154410	Amphibolite	10	130	40	10	N.D.	<0.01	N.A.
96RME-0458	527200	5154370	Amphibolite	180	51	110	N.D.	N.D.	<0.01	N.A.
96RME-0459	527200	5154370	Amphibolite	160	40	95	N.D.	N.D.	<0.01	N.A.
96RME-3020	531976	5162009	Amphibolite	120	71	69	N.D.	N.D.	<0.01	N.A.
96RME-3027	531934	5161604	grt amphibolite	14	100	30	N.D.	N.D.	0.07	N.A.
96RME-3029	532010	5161490	grt amphibolite	9	20	20	N.D.	28	0.01	N.A.
96RME-3127	531[illegible]4	5161604	grt amphibolite	7	57	20	N.D.	N.D.	0.01	N.A.
Huronian metavolcanic and dike rocks										
96RME-0123	532820	5162930	Mafic metavolcanic	81	83	77	N.D.	N.D.	<0.01	N.D.
96RME-0124	532849	5162892	felsic metavolcanic	38	12	16	N.D.	N.D.	0.12	N.D.
96RME-0233	531900	5162120	grt amphibolite dike	38	180	65	N.D.	N.D.	<0.01	N.A.
96RME-0447	532760	5162995	Mafic metavolcanic	120	150	81	16	N.D.	0.08	N.D.
96RME-0448	532820	5162800	Mafic metavolcanic	5	10	9	N.D.	N.D.	0.04	N.D.
96RME-3004	532009	5162502	Mafic metavolcanic	63	290	73	N.D.	N.D.	0.21	6
96RME-3030	531960	5162357	Schist	41	9	30	N.D.	N.D.	0.01	N.D.
96RME-3031	531900	5162260	Schist	140	40	54	N.D.	N.D.	0.05	N.D.
96RME-3032	532200	5162530	Schist	61	9	20	N.D.	N.D.	0.01	N.D.
Nipissing gabbro (unit 18)										
96RME-0439	524725	5155250	Gabbronorite (Street occurrence #1)	77	1560	2915	N.A.	N.A.	N.A.	2700
96RME-0446	532980	5162960	Gabbronorite	240	50	110	24	13	0.02	N.A.
Non-migmatitic amphibolite (Mg#=35-59, possible Nipissing gabbro (unit 18)?)										
96RME-0449	532668	5162632	Amphibolite	16	50	30	N.D.	N.D.	0.03	N.A.
96RME-3148	533000	5162870	Amphibolite	17	20	20	N.D.	N.D.	0.02	N.A.
96RME-3150	532900	5162660	Amphibolite	59	310	50	15	17	0.03	N.A.
96RME-3151	532120	5162420	Amphibolite	30	72	50	N.D.	N.D.	<0.01	N.A.
Non-migmatitic amphibolite (Mg#>60, possible high-Mg Nipissing gabbro?) (unit 7 or 18)										
96RME-0457	527405	5154440	Amphibolite	830	54	190	N.D.	N.D.	<0.01	N.A.
96RME-0460	527940	5153600	Amphibolite	760	52	140	N.D.	N.D.	<0.01	N.A.
96RME-1056	529260	5159000	Amphibolite	981	35	170	30	21	<0.01	N.A.
96RME-3147	532900	5162840	Amphibolite	750	10	140	11	N.D.	<0.01	N.A.
Orthopyroxene hornblendite (unit 6)										
96RME-0041	528938	5157144	opx hornblendite	>3000	160	870	7	N.D.	0.01	N.A.
96RME-0267	524960	5153570	opx hornblendite	>3000	16	850	N.D.	N.D.	<0.01	N.A.
96RME-0341	528270	5153690	opx hornblendite	2900	N.D.	880	N.D.	N.D.	<0.01	N.A.
96RME-0341B	528270	5153690	opx hornblendite	5087	<100	955	12	11	N.A.	4
97RME-0033	325400	5151800	opx hornblendite	~4000	9	750	N.A.	N.A.	<0.01	N.A.

Abbreviations: grt = garnet, opx = orthopyroxene, N.D. = not detected, N.A. = not analyzed.
* number in brackets indicates detection limit for the respective element

Table 16. Assay results from East Bull Lake intrusive suite rocks (units 6, 7, 8) from Street Township. See Figure 22b for a sample location map.

Sample No.	Easting	Northing Zone 17T	Field Rock Name	Cr ppm (4)*	Cu ppm (5)*	Ni ppm (5)*	Pt ppb(5)*	Pd ppb(10)*	S wt %	Au ppb(3)*
96RME-0200	529378	5154441	Amphibolite	1134	68	170	24	25	0.02	N.A.
96RME-0213	530640	5155255	Gabbroic anorthosite	48	31	73	72	40	<0.01	N.A.
98RME-0022	529782	5154944	Anorthositic gabbro	40	188	35	10	<10	<0.01	N.A.
98RME-0023	530055	5155115	Gabbroic anorthosite	66	151	64	27	32	<0.01	N.A.
98RME-0024	530387	5155360	Anorthositic gabbro	452	7	141	64	102	<0.01	N.A.
98RME-0025	530469	5155301	Gabbroic anorthosite	117	119	60	25	13	<0.01	N.A.
98RME-0026	530880	5155487	Anorthositic gabbro	54	100	42	7	18	N.A.	N.A.
98RME-0027	531137	5155400	Amphibolite	103	157	117	<5	<10	0.05	N.A.
98RME-0028	531358	5155265	Anorthositic gabbro	60	72	34	10	<10	N.A.	N.A.
98RME-0030	530760	5155098	Leuconorite	133	158	134	<5	<10	0.03	N.A.
98RME-0031	530549	5155130	hbl pegmatite	74	12	31	<5	<10	0.01	N.A.
98RME-0032	530443	5155040	Anorthositic gabbro	25	178	33	7	<10	N.A.	N.A.
98RME-0038	530178	5154729	Border zone, amphibolite	384	156	160	7	11	0.04	N.A.
98RME-0047	530433	5154949	Amphibolite	87	80	98	<5	<10	0.05	N.A.
98RME-0048	530433	5154949	Garnet amphibolite	94	48	73	<5	<10	<0.01	N.A.
98RME-0049	530550	5155060	opx hornblendite	1030	44	869	<5	<10	<0.01	N.A.
98RME-0050	530475	5154989	Gabbroic anorthosite	58	81	31	11	19	<0.01	N.A.
98RME-0051	534000	5155075	Anorthositic gabbro	51	169	74	<5	<10	0.04	N.A.
98RME-0052	530268	5155150	Leuconorite	104	152	113	<5	<10	0.04	N.A.
98RME-0053	530240	5155175	Amphibolite	92	52	111	<5	<10	0.01	N.A.
98RME-0054	530050	5155630	Gneiss anor gabbro	75	5	73	12	25	N.A.	N.A.
98RME-0055	530100	5155360	Hornblendite	1018	N.D.	864	<5	<10	<0.01	N.A.
98RME-0056	530100	5155360	Anorthositic gabbro	283	6	119	36	46	N.A.	N.A.
98RME-0062	530650	5155060	Leuconorite	474	73	140	16	22	0.03	N.A.
98RME-0064	530650	5155250	Anorthositic gabbro	51	16	58	85	144	N.A.	N.A.
98RME-0073	530050	5155025	Anorthositic gabbro	40	105	35	<5	12	N.A.	N.A.
98RME-0074	529975	5155060	Anorthositic gabbro	45	150	55	14	24	<0.01	N.A.

Abbreviations: hbl = hornblende, opx = orthopyroxene, N.D. = not detected, N.A. = not analyzed. * number in brackets indicates detection limit for the respective element.

The 2 additional samples with the highest PGE contents, 98RME-0024 and 98RME-0064, contain 166 and 229 ppb combined platinum and palladium, respectively. These samples were collected from the same area of the Street metagabbro as sample 96RME-0213 and indicate that there may be a discrete mineralized horizon in this part of the intrusion. There is no obvious relationship between PGE content and nickel, copper or sulphur contents in these 3 samples. Four additional samples showing atypical PGE values are 98RME-0023, 98RME-0054, 98RME-0056 and 98RME-0073, which contain 59, 37, 82 and 38 ppb combined platinum and palladium, respectively. These 4 samples were collected from the northwest margin of the Street metagabbro.

The additional sampling in 1998 indicated that initial sampling was reliable and that atypical PGE values occur in 2 areas of the Street metagabbro, namely the central core and the northwest margin. All samples with combined platinum and palladium greater than 37 ppb are from anorthositic gabbro or gabbroic anorthosite, as is the case in the East Bull Lake intrusion (Peck et al. 1995).

RECOMMENDATIONS FOR MINERAL EXPLORATION

Easton (1996) suggested that garnet-rich gneisses being evaluated for industrial mineral purposes may represent hydrothermally altered metavolcanic rocks similar to those present in the Manitouwadge camp (e.g., Zaleski et al. 1995). As discussed previously, relative age relationships suggest that the original protolith for these rocks was Archean in age.

Between 1982-1984, the Watt-McLean team discovered interesting sulphide mineralization in an area between the Ess Creek fault and the Grenville Front boundary fault of Lumbers (1973). This mineralization is hosted in mafic and felsic metavolcanic rocks of the Stobie Formation which have an FIII-type geochemical signature (Easton 1998). In Archean and younger terranes, FIII-type rhyolites are commonly associated with volcanogenic massive sulphide mineralization (e.g., Lesher et al. 1986; Parker and Ayer 1997; Hart et al. 2001). Consequently, this earlier defined diamond-drill target should be re-examined. In addition, Easton and Hrominchuk (1999) reported the presence of similar felsic metavolcanic rocks, 25 km to the east, at the McNish-Dana Township boundary near the community of River Valley. Thus, the area between the Ess Creek fault and the Grenville Front boundary fault, between Street and Dana townships, should be considered as a possible target zone for volcanogenic massive sulphide mineralization hosted within Huronian metavolcanic rocks.

Gold and copper mineralization, associated with sodium-metasomatism along regional fault structures (e.g., McVittie and Boulanger–Potvin occurrences), is a viable exploration target with past-producing gold mines (e.g., Scadding Gold Mine, Gates 1991) being located immediately north of the map area in Scadding Township. Exploration should focus on the major northwest-striking fault systems cutting the western part of Street Township.

During 1988-89, Midway Mines and Energy Ltd. examined a six-claim group property in southwest Street Township (*see* Table 11). Sulphide mineralization was present at the contact between a Nipissing gabbro sill and arenites of the Serpent Formation. The metasediments were strongly altered (silicified) and locally contained gold. In addition, exploration pits of unknown age, located near the southern contact of the same Nipissing gabbro, locally contain gabbro altered to hydrous phases and asbestiform tremolite. Neither the contact zone with the metasedimentimentary rocks or the altered gabbro have been prospected for PGE mineralization. The hydrous alteration of the gabbro suggests the possibility of hydrothermal-style PGE mineralization, similar to that present at the Rathburn occurrence, approximately 20 km to the north-northeast and currently being examined by Flag Resources Inc.

Easton (1999a) previously noted that the East Bull Lake intrusive suite, in southwest Street Township, are locally anomalous in PGE. Greater potential for PGE mineralization in rocks of this suite occurs east of Street Township in Loughrin, Henry, Dana and Crerar townships where the main mass of the areally extensive River Valley Intrusion is present. PGE exploration in the East Bull Lake intrusive suite has focussed mainly on a contact mineralization model (e.g., Hrominchuk 2000, James et al. 2002).

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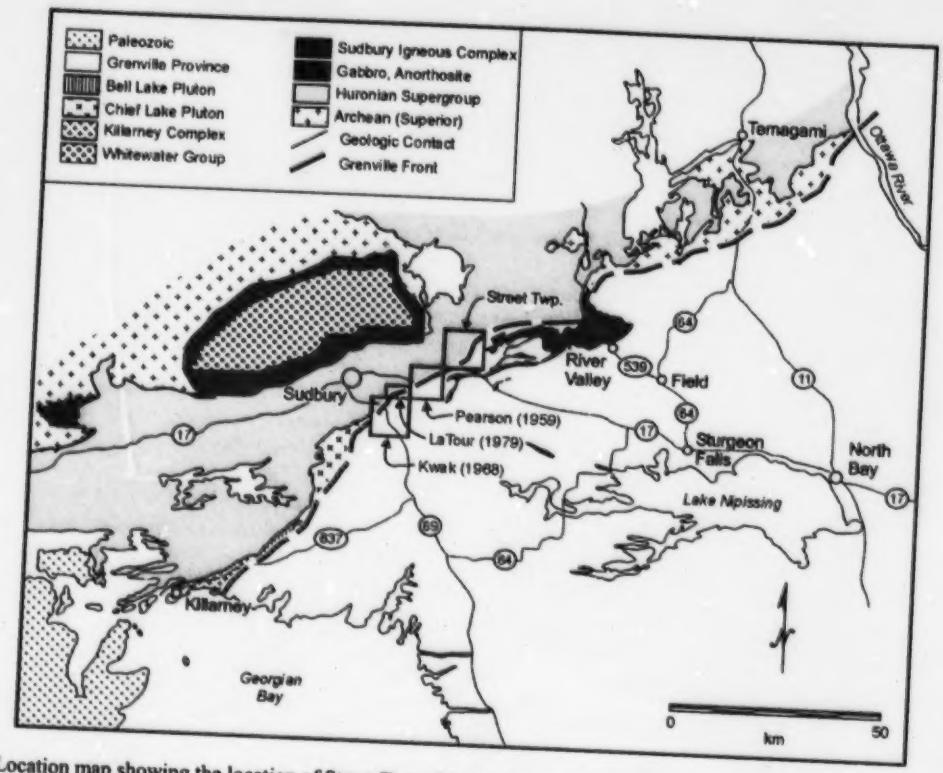


Figure 1. Location map showing the location of Street Township (study area) as well as areas studied by Kwak (1968), La Tour (1979) and Pearson (1959).

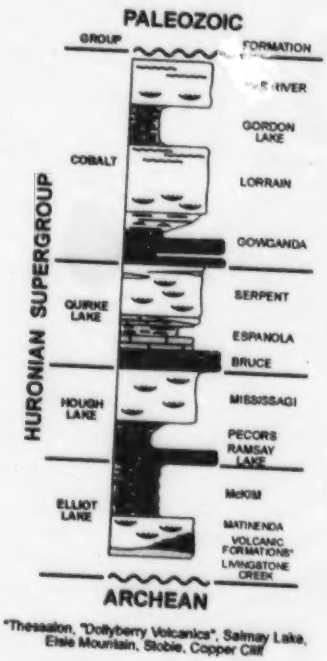


Figure 2. Stratigraphic column of the Huronian Supergroup (*modified from* Jackson 2001; Bennett, Dressler and Robertson 1991).

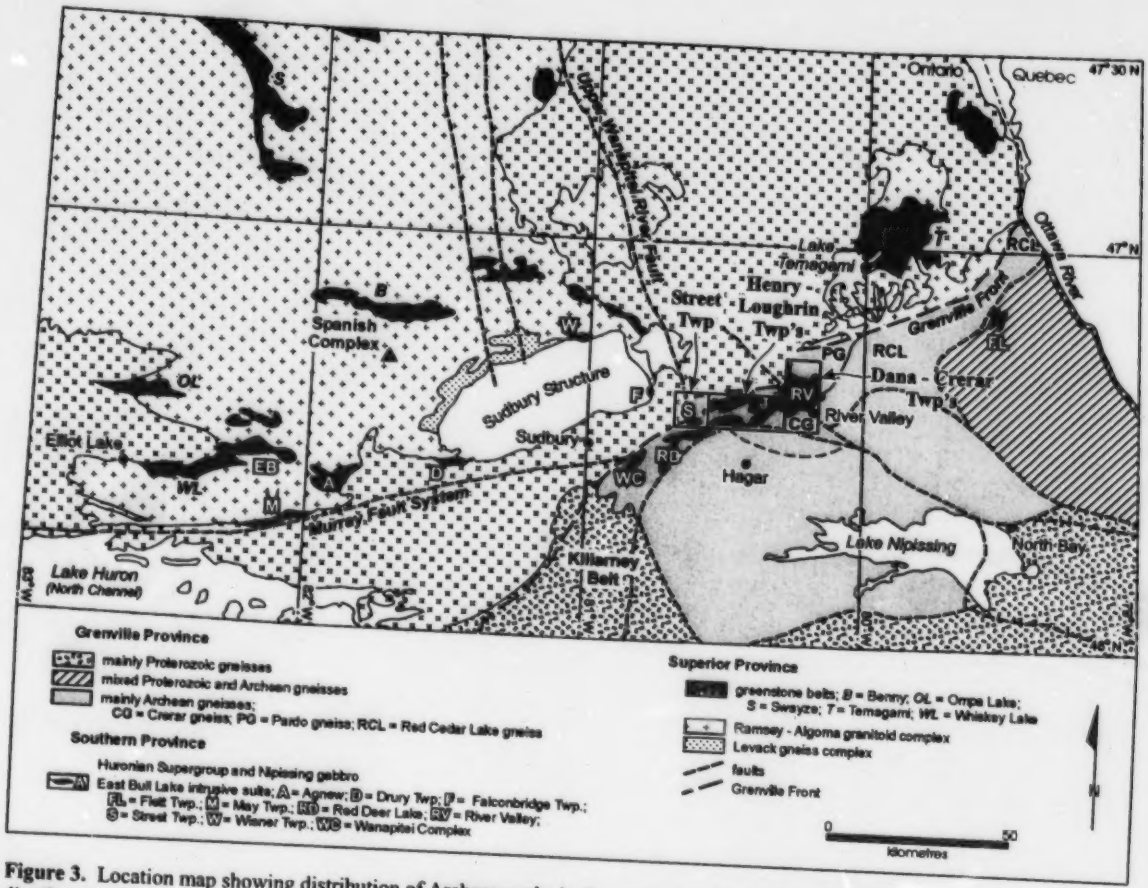
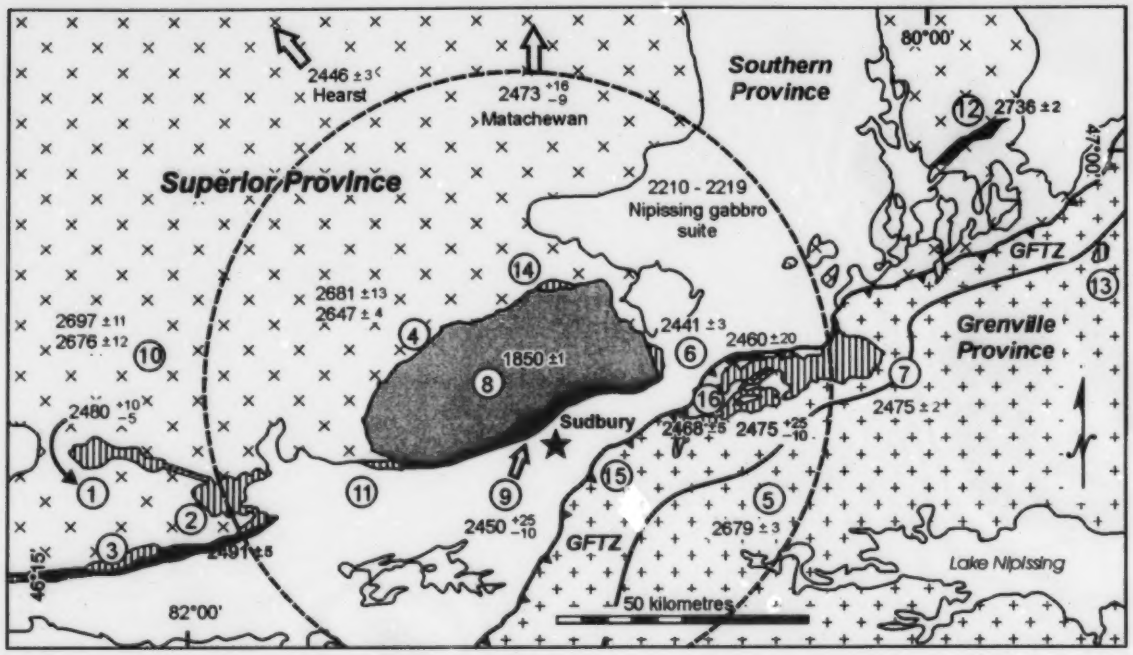

Ontario
Quebec
47° 30 N
47°N
46°N
Lake Temagami
Ottawa River
Grenville Front
Henry - Loughrin Twp's.
Street Twp
Spanish Complex
Sudbury Structure
Sudbury
Dana - Crerar Twp's.
River Valley
Hagar
Lake Nipissing
North Bay
Elliot Lake
Murray Fault System
Killarney Belt
Lake Huron (North Channel)
Grenville Province
mainly Proterozoic gneisses
mixed Proterozoic and Archean gneisses
mainly Archean gneisses;
CG = Crerar gneiss; PG = Pardo gneiss; RCL = Red Cedar Lake gneiss
Southern Province
Huronian Supergroup and Nipissing gabbro
East Bull Lake intrusive suite; A = Agnew; D = Drury Twp; F = Falconbridge Twp.; FL = Flett Twp.; M = May Twp.; RD = Red Deer Lake; RV = River Valley; S = Street Twp.; W = Wisner Twp.; WB = Wanapitei Complex
Superior Province
greenstone belts; B = Benny; OL = Ompa Lake; S = Swayze; T = Temagami; WL = Whiskey Lake
Ramsey - Algoma granitoid complex
Levack gneiss complex
faults
Grenville Front
0
50
kilometres

Figure 3. Location map showing distribution of Archean rocks in the south-central Canadian Shield in Ontario, as well as the distribution of rocks of the East Bull Lake intrusive suite. Proterozoic intrusive rocks within the Grenville Province have been omitted for clarity. *Modified from* Ontario Geological Survey (1992b, 1992c), Lumbers (1971, 1973, 1975).



1. East Bull Lake intrusion
2. Agnew Lake intrusion
3. May Twp. intrusion
4. Levack gneiss plutonism + metamorphism
5. Warren tonalite gneiss
6. Falconbridge Twp. intrusion
7. River Valley intrusion
8. Sudbury Igneous Complex
9. Copper Cliff rhyolite
10. Archean basement
11. Drury Twp. intrusion
12. Temagami Island Gabbro
13. Flett Twp. intrusions
14. Wisner Twp. intrusion
15. southern Wanapitei complex
16. Sreet Twp. intrusion

Grenville Province rocks
Huronian metasedimentary rocks
Huronian volcanic rocks
EBLI suite rocks
Superior Province rocks

Figure 4. Distribution of U/Pb zircon ages from Neoarchean and Paleoproterozoic rocks in the Sudbury area. Dashed circle indicates 125 km radius from a point central to the Sudbury Structure, most intrusions lie within this radius. Sources used: 1, 2, 8, 9) Krogh, Davis and Corfu 1984; 4) Wodicka & Card 1995; Krogh, Davis and Corfu 1984; 5) Chen, Krogh and Lumbers 1995; 6 & 10) Prevec 1993; 7) Heaman in Easton, Davidson and Murphy 1999; below and above circle 16, Corfu and Easton (2000). Age of Hearst and Matachewan dikes *from* Heaman (1997).

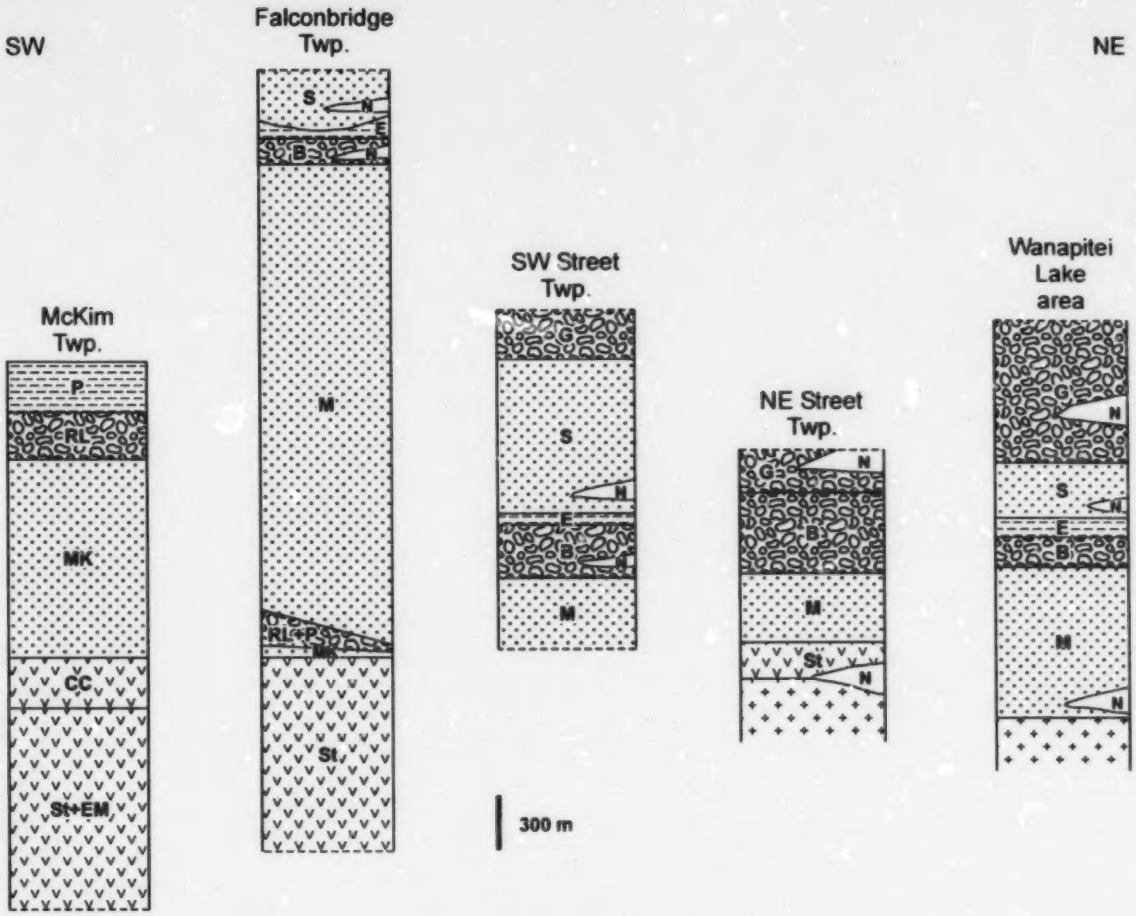
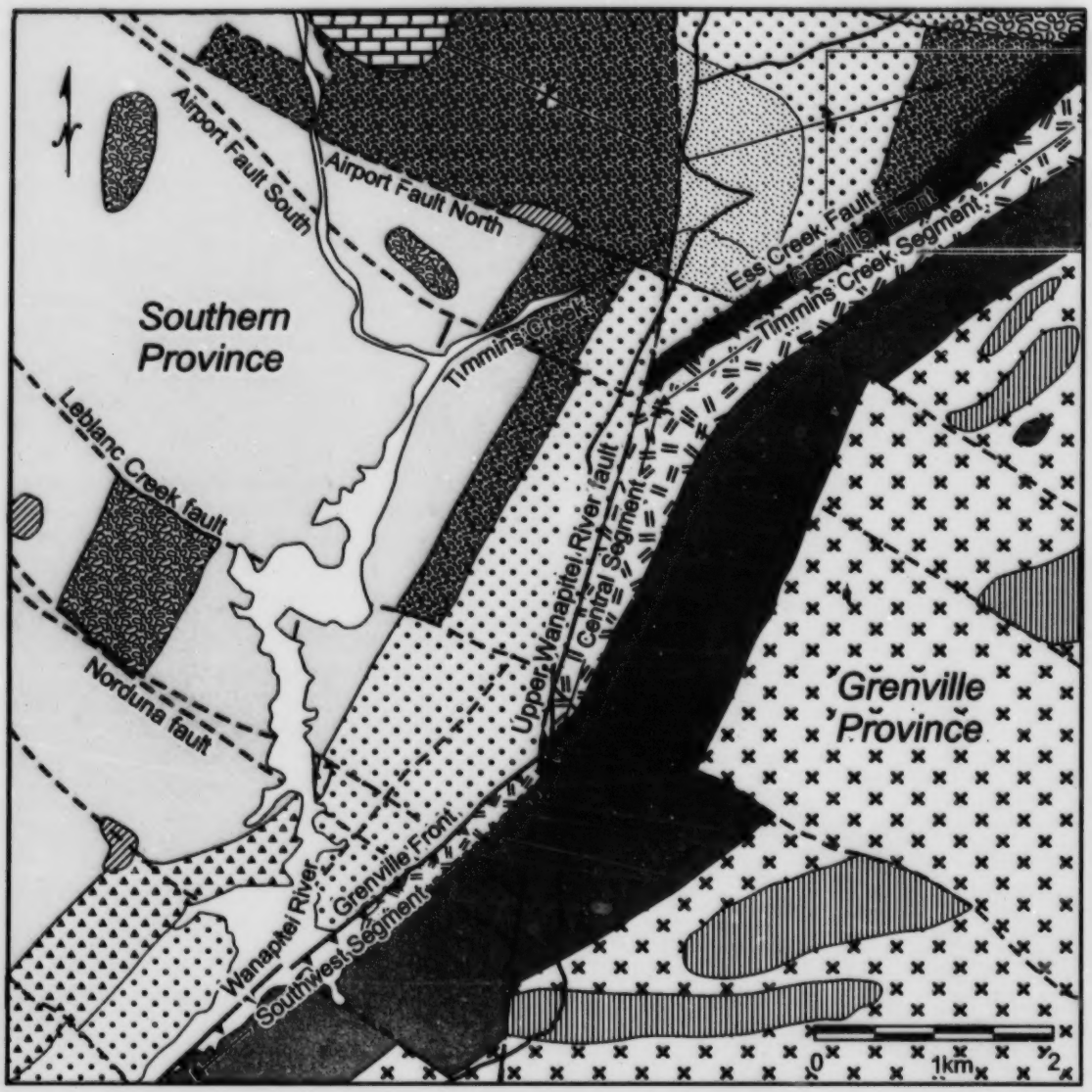


Figure 5. Variation in the thickness of the Huronian Supergroup east of Sudbury. Data *from* Debicki (1990) and this study. Abbreviations: B = Bruce Formation, CC = Copper Cliff Formation; E = Espanola Formation, EM = Elsie Mountain Formation, G = Gowganda Formation, M = Mississagi Formation, MK = McKim Formation, N = Nipissing gabbro, P = Pecors Formation, RL = Ramsay Lake Formation, S = Serpent Formation, St = Stobie Formation. Cross pattern indicates granitic basement.



Grenville Province

- Domain 1: garnet-biotite (+ or - kyanite) gneiss and amphibolite with a strong foliation parallel to the Grenville Front
- Domain 2: migmatitic and non-migmatitic amphibolite (+ or -), quartzofeldspathic garnet gneiss (+ or - kyanite, muscovite), and Sudbury metadiabase
- Domain 3: migmatitic quartzofeldspathic gneiss which wrap around dominantly non-migmatitic rocks of domain 4
- Domain 4: clinopyroxene - bearing coarse grained amphibolite and anorthositic gabbro, and migmatitic granitic gneiss

Southern Province

- Nipissing Gabbro
- Cobalt Group: Gowganda Formation
- Quirke Lake Group: Serpent Formation
- Quirke Lake Group: Espanola Formation
- Quirke Lake Group: Bruce Formation
- Hough Lake Group: Mississagi Formation
- Hough Lake Group: Pecors Formation

- Transitional Zone
- zone of silicification and Na-metasomatism
- geological contact
- fault
- Study area (Murphy 1999, 2001)

Figure 6. Simplified geological map of Street Township.

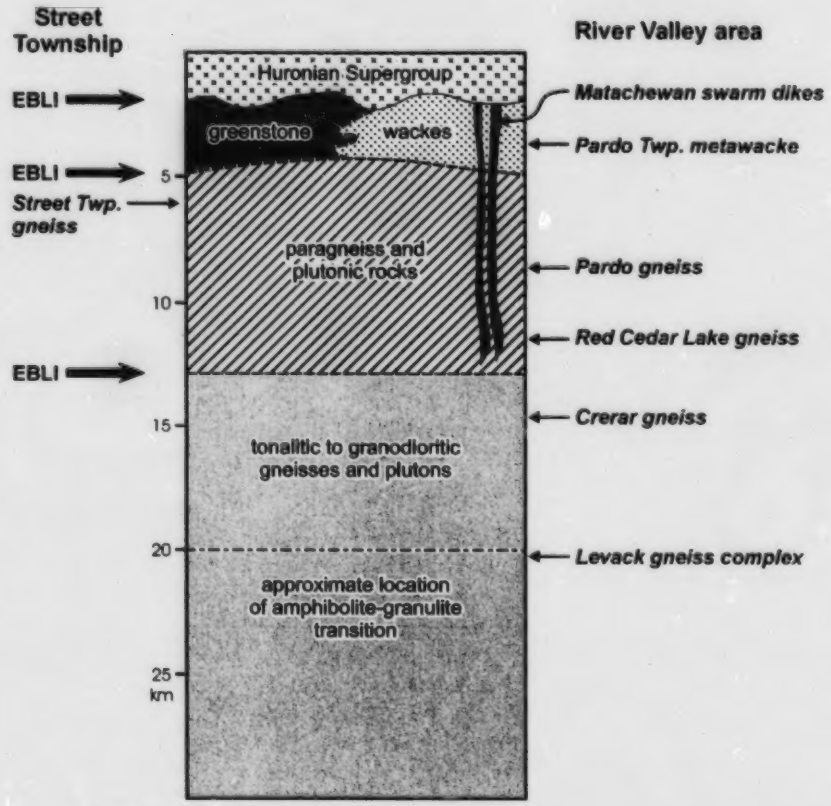


Figure 7. Cartoon *from* Easton (2000) illustrating the exposed crustal section in the Street Township and River Valley areas. Possible emplacement levels for rocks of the East Bull Lake intrusive suite are illustrated (see text for discussion).

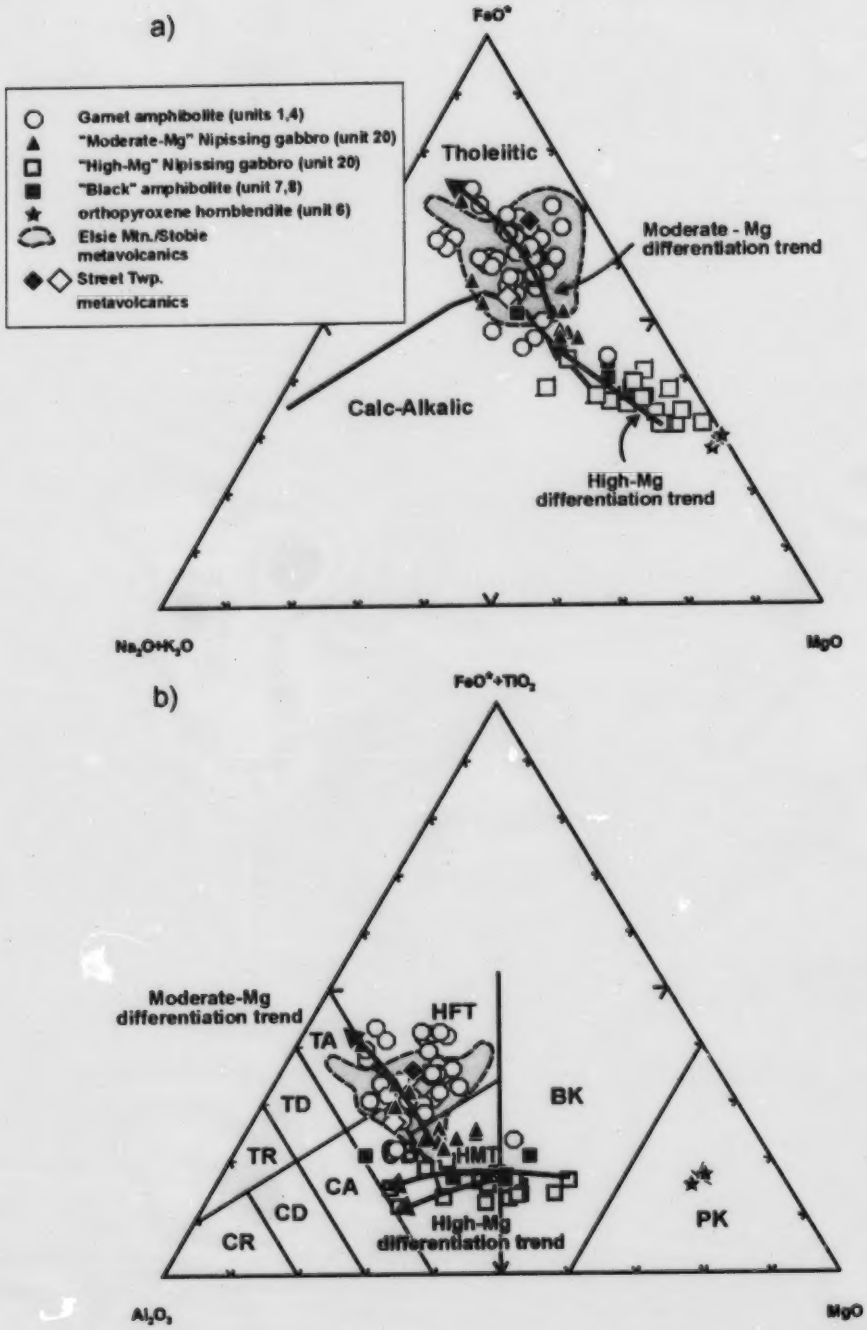


Figure 8. Geochemical data for mafic rocks from the study area (data *from* this study, Pearson 1959, and La Tour 1979). North of the Grenville Front, units historically mapped as Nipissing gabbro are of both the moderate MgO and high MgO types. These two types of Nipissing gabbro are also present south of the Grenville Front. **a)** AFM diagram. **b)** Jensen diagram. In this and subsequent Jensen diagrams, abbreviations are: BK = basaltic komatiite; CB, CA, CD, CR = calc-alkalic basalt, andesite, dacite and rhyolite, respectively; HFT = High iron tholeiite; HMT = high magnesium tholeiite; PK = peridotitic komatiite; TA, TD, TR = tholeiitic andesite, dacite and rhyolite, respectively.

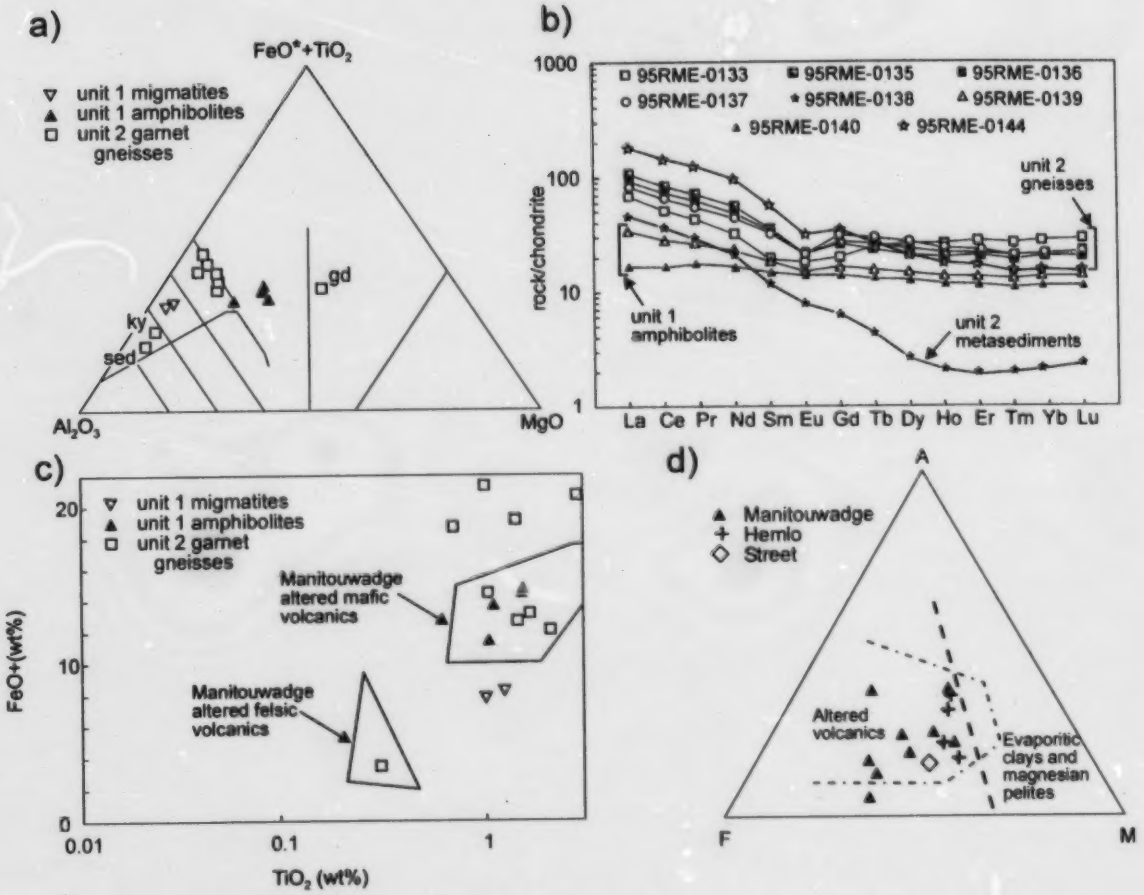


Figure 9. Geochemical plots for Street Township garnetifereous gneisses of units 1 to 3. Abbreviations: gd = gedrite, ky = kyanite, sed = metasediment. **a)** Jensen diagram for samples from domain 2. **b)** Chondrite-normalized rare earth element plot for representative samples from domain 2. **c)** FeO^t versus log TiO_2 plot for samples from domain 2. Fields of altered and unaltered rocks from Manitouwadge are *from* Zaleski et al. (1995). **d)** AFM plot (molar proportions) for gedrite-bearing sample from Street Township compared with field for altered volcanics, magnesian pelites, and data from Manitouwadge and Hemlo (*modified from* Zaleski et al. 1995).

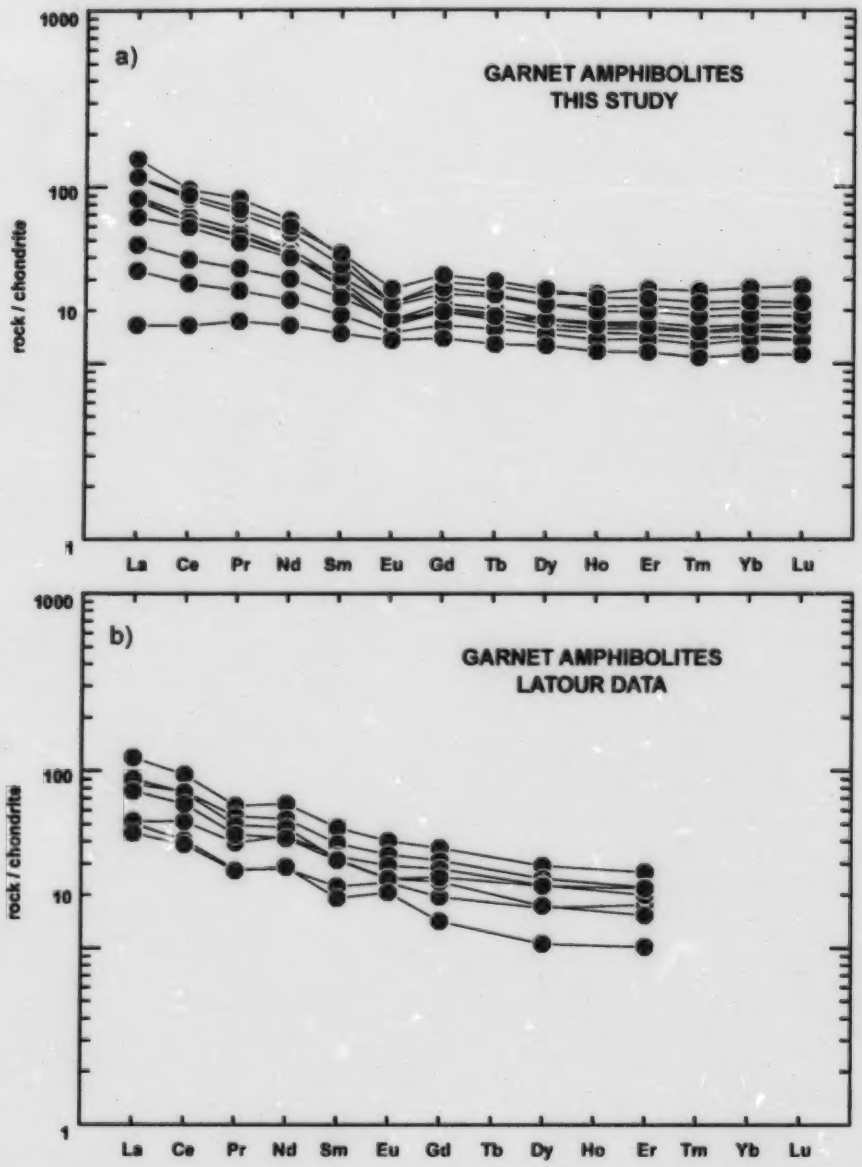


Figure 10. Chondrite-normalized rare-earth element plots for garnet amphibolites of unit 1 from the Sudbury–Street Township area. Data *from* **a)** this study and **b)** La Tour (1979). REE patterns for the garnet amphibolites are consistent with either an Archean or Huronian Supergroup source. Lack of REE data on the Stobie and Elsie Mountain formations prevents direct comparison with possible Huronian Supergroup sources.

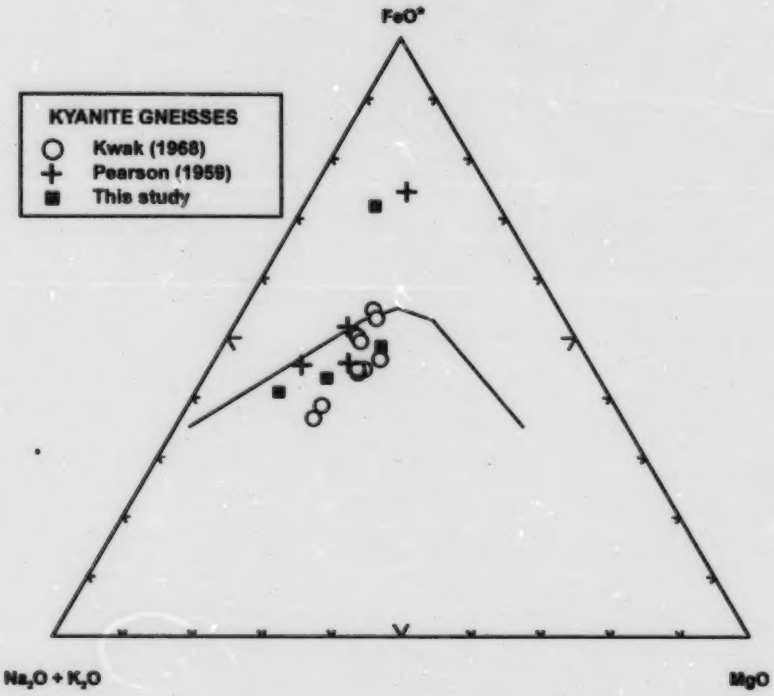


Figure 11. Geochemical characteristics of kyanite-bearing gneisses from the Sudbury–Street Township area. Data *from* this study, Kwak (1968) and Pearson (1959). The AFM plot shows a grouping into high-Fe and lower Fe types. The high-Fe types may have been derived from altered mafic metavolcanic rocks.

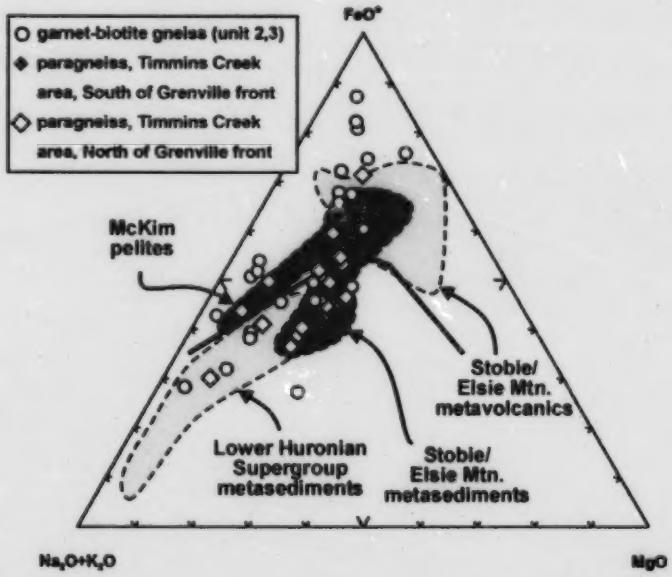


Figure 12. Geochemical characteristics of garnet-biotite gneisses (units 2 and 3) from the Sudbury–Street Township area. Data for schists and paragneiss (units 11 to 13) from the Timmins Creek area are also shown. Data *from* this study, Kwak (1968), and Pearson (1959). The AFM plot also provides comparison with the fields of possible source rocks. Note: that the garnet-bearing gneisses of units 2 and 3 do not clearly fall in any Huronian Supergroup field. In contrast, paragneisses from the Timmins Creek area show overlap with either fields of McKim or lower Huronian Supergroup pelites or with Stobie-Elsie Mountain formation metasedimentary rocks.

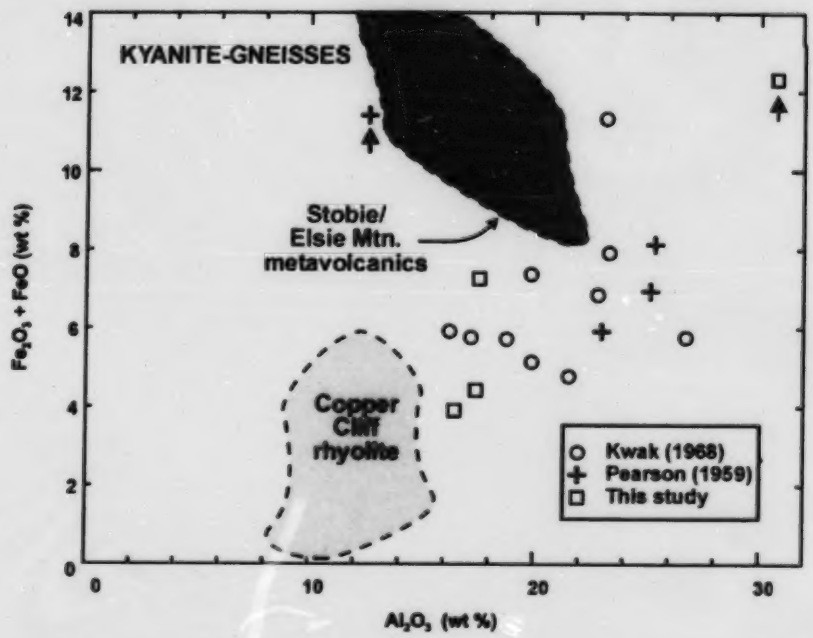


Figure 13. Geochemical characteristics of kyanite-bearing gneisses from the Sudbury–Street Township area. Data *from* this study, Kwak (1968) and Pearson (1959). Plot of total iron versus Al_2O_3 showing that kyanite-gneisses of either type do not overlap with the fields of typical Huronian Supergroup metavolcanic rocks.

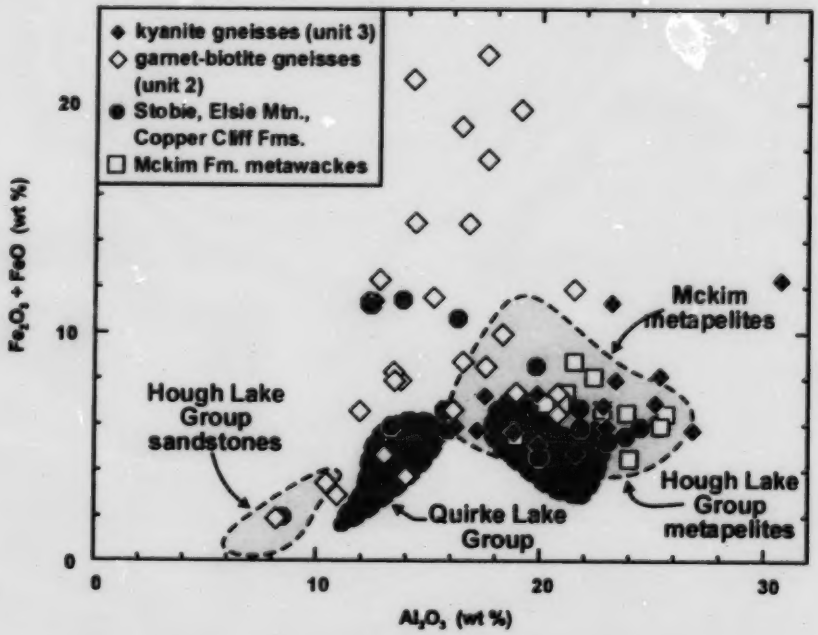


Figure 14. Geochemical characteristics of paragneiss (units 2 and 3) and kyanite-bearing gneisses from the Sudbury–Street Township area. Data *from* this study, Kwak (1968) and Pearson (1959). Plot of total iron versus Al_2O_3 showing overlap of kyanite-gneisses with fields for McKim Formation pelites and Stobie Formation metasedimetary rocks (data *from* Innes 1972). Note that garnet-biotite gneisses of unit 2 are characterized by high-Fe contents compared to the other units, and show little affinity to the Huronian Supergroup metasedimentary rocks. The composition range of other lower Huronian Supergroup metasedimentary rocks is shown for comparison.

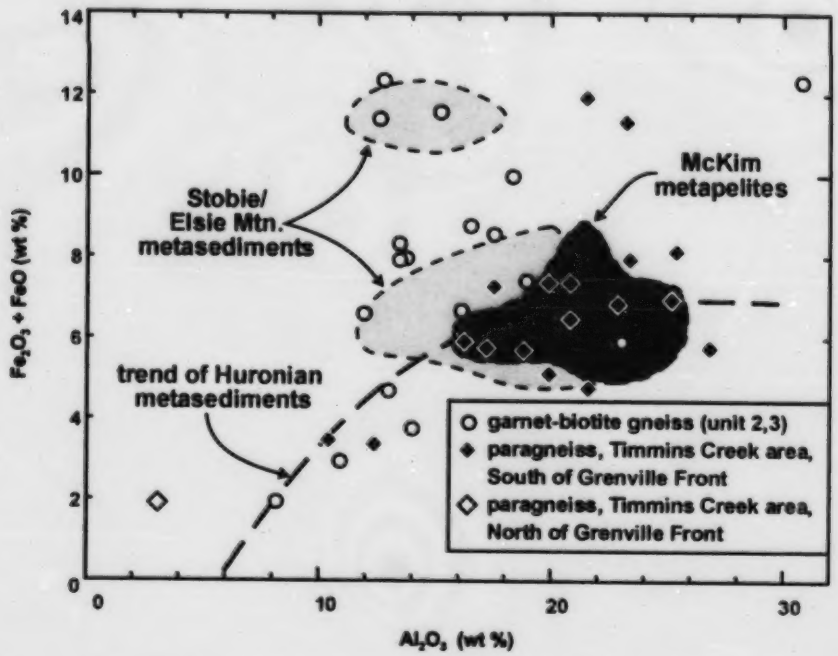


Figure 15. Geochemical characteristics of garnet-biotite gneisses (units 2 and 3) from the Sudbury–Street Township area. Data for schists and paragneiss (units 11 to 13) from the Timmins Creek area are also shown. Data *from* this study, Kwak (1968), and Pearson (1959). Plot of total iron versus Al_2O_3 shows overlap of some of the Timmins Creek schists and gneisses with the field for McKim pelites, but not with other Lower Huronian Supergroup sediments. Note the large scatter in the garnet-biotite gneiss samples (Units 2 and 3) and no clear correspondence with any Huronian Supergroup unit.

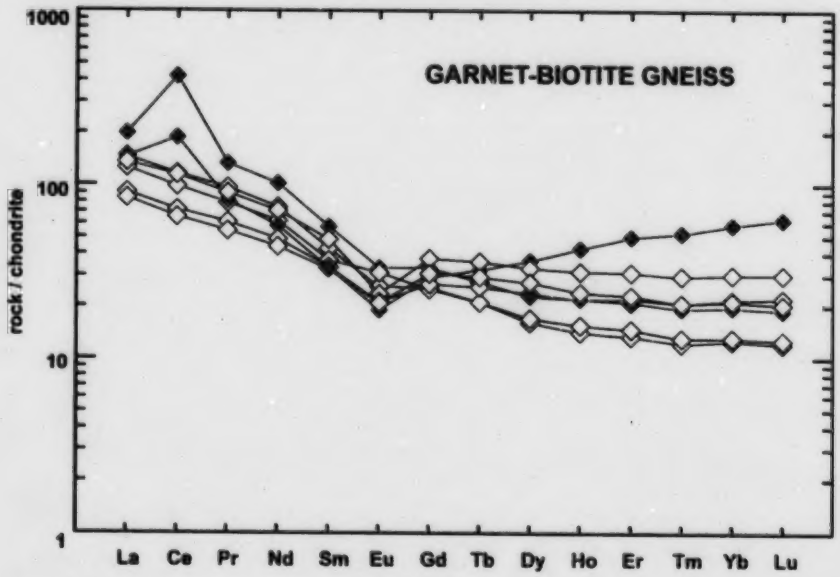


Figure 16. Geochemical characteristics of garnet-biotite gneisses (units 2 and 3) from Street Township. Chondrite-normalized rare-earth element plots for garnet-biotite gneisses (unit 2, open diamonds) and felsic gneisses (unit 3, filled diamonds). Note similarity of REE patterns for the open diamonds with those of the more differentiated garnet amphibolites (unit 1) from Street Township (compare with Figure 10). Note the positive cerium anomalies in some of the felsic gneisses (filled diamonds). Such anomalies are characteristic of oxidizing environments, such as those found in paleosols. These anomalies suggest that some of the garnet-biotite gneisses may represent former paleosols.

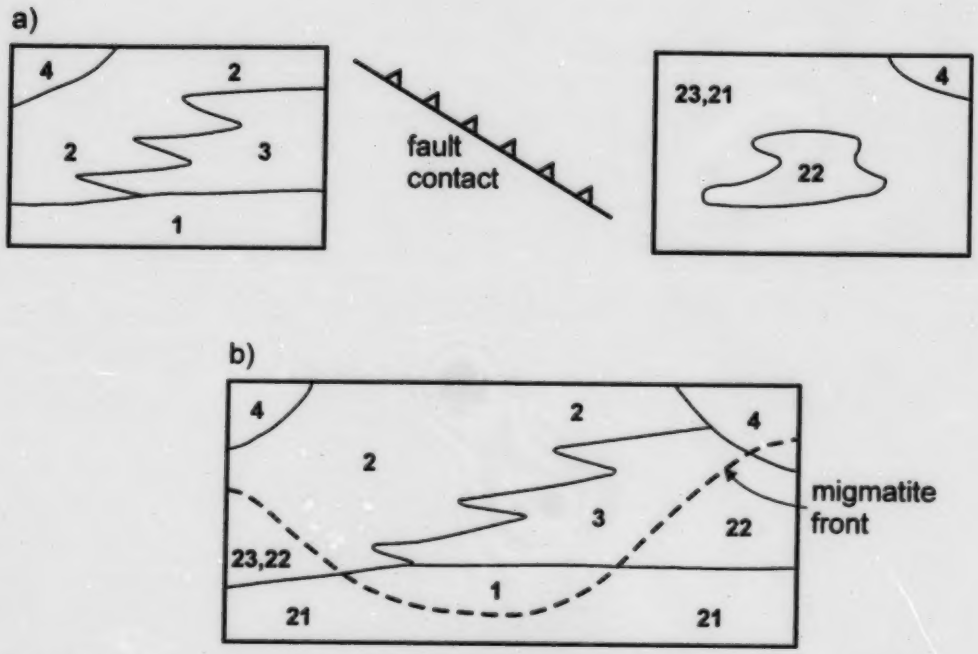


Figure 17. Sketch showing possible stratigraphic relationships between units 1 to 4 and 21 to 23. **a)** fault model. **b)** units only differ in the degree of migmatitization. Migmatitic to metatextitic gneisses of units 1 to 4 consist of mafic gneiss (unit 1), biotite-garnet gneiss (unit 2), felsic and aluminous gneiss (unit 3), and mafic orthogneiss (unit 4). Diatextitic gneises of unit 21 to 23 consist of mafic (unit 21), intermediate (unit 22) and felsic (unit 23) types.

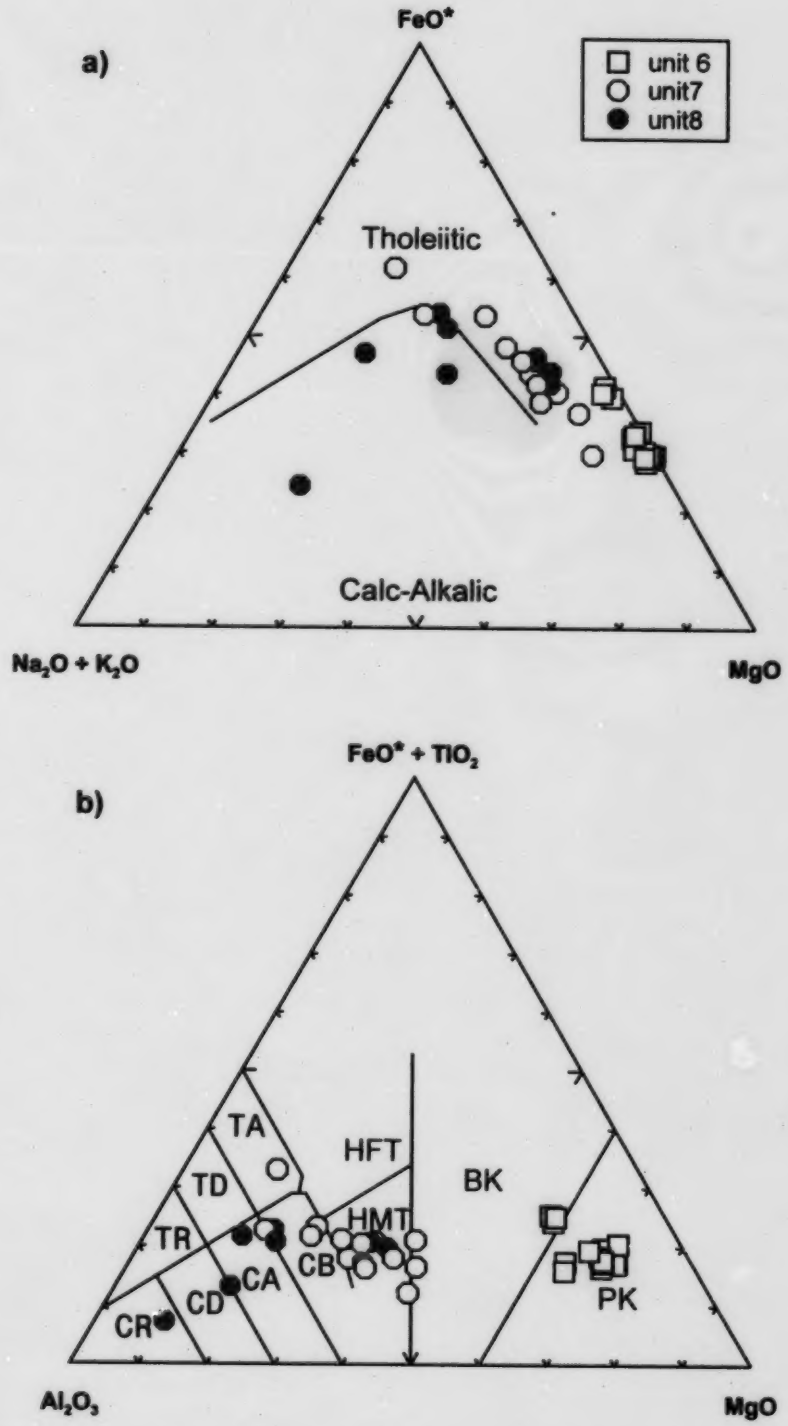


Figure 18. AFM (upper) and Jensen (lower) diagrams for orthopyroxene hornblendites (unit 6) from Street Township. Shown for comparison are other East Bull Lake intrusive suite rocks (units 7 and 8) from Street Township. Figure 9a and b compares the orthopryoxene hornblendites with mafic volcanic rocks of the Stobie Formation from the Sudbury and Street Township areas.

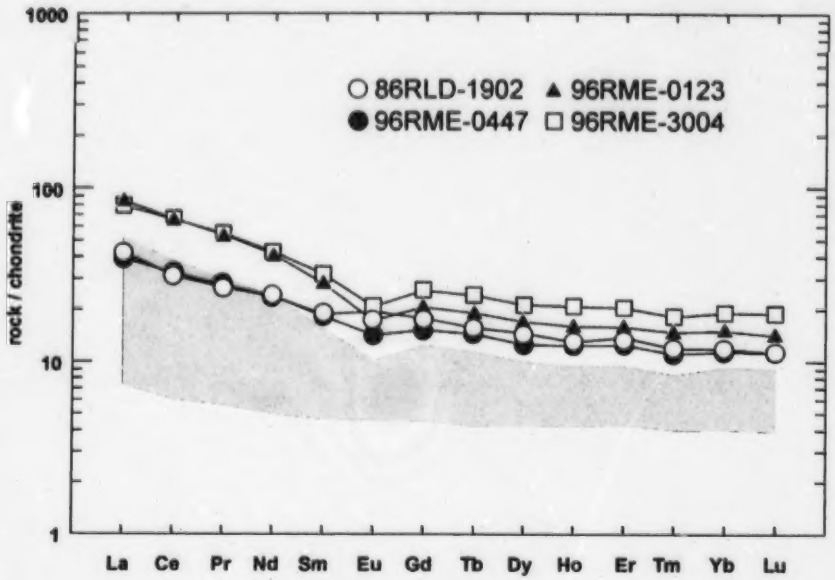


Figure 19. Chondrite-normalized rare earth element plots for mafic volcanic rocks of the Stobie Formation (unit 10) from the Sudbury and Street Township areas and East Bull Lake intrusive suite rocks from (units 7 and 8) from Street Township. The plot shows data for various Stobie basalts (sample 86RLB-1902 is from the Sudbury area, the others are from Street Township) compared to the field for the East Bull Lake intrusive suite samples.

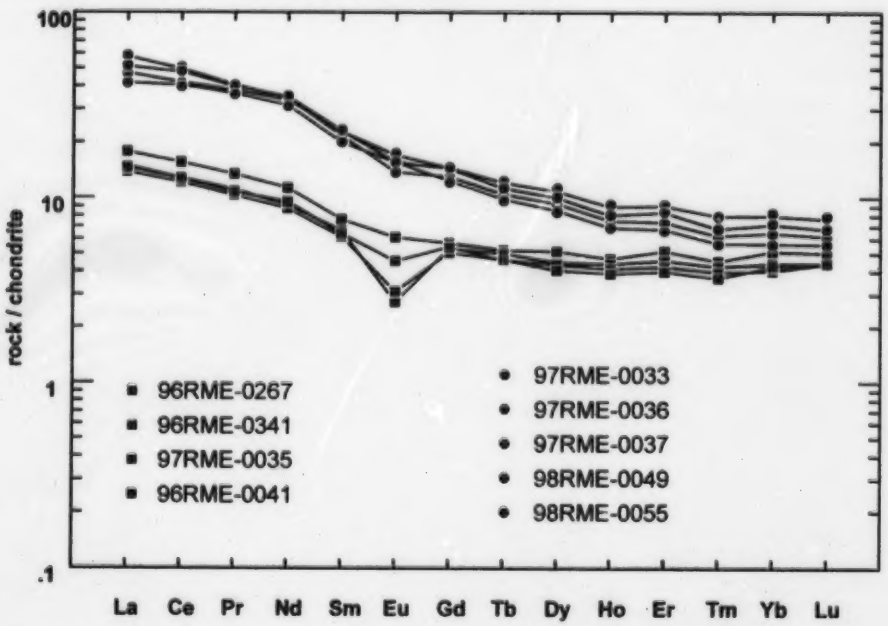


Figure 20. Chondrite-normalized rare earth element plots for 9 orthopyroxene hornblendite samples from Street Township. Note the orthopyroxene hornblendites fall into two groups, one characterized by prominent Eu anomalies and only slighlt enriched LREE contents, the other characterized by moderately enriched LREE contents and no Eu anomaly. The rare earth element patterns for both groups of hornblendites are similar to those for other East Bull Lake intrusive rocks (see Figure 23), however, the hornblendites are not the most primitive rocks within the East Bull Lake intrusive suite. In combination with the trace element chemistry of the hornblendites (e.g., Zr, Y, P contents) the rare earth element data suggest that the orthopyroxene hornblendites were derived from evolved, rather than primitive, magmas.

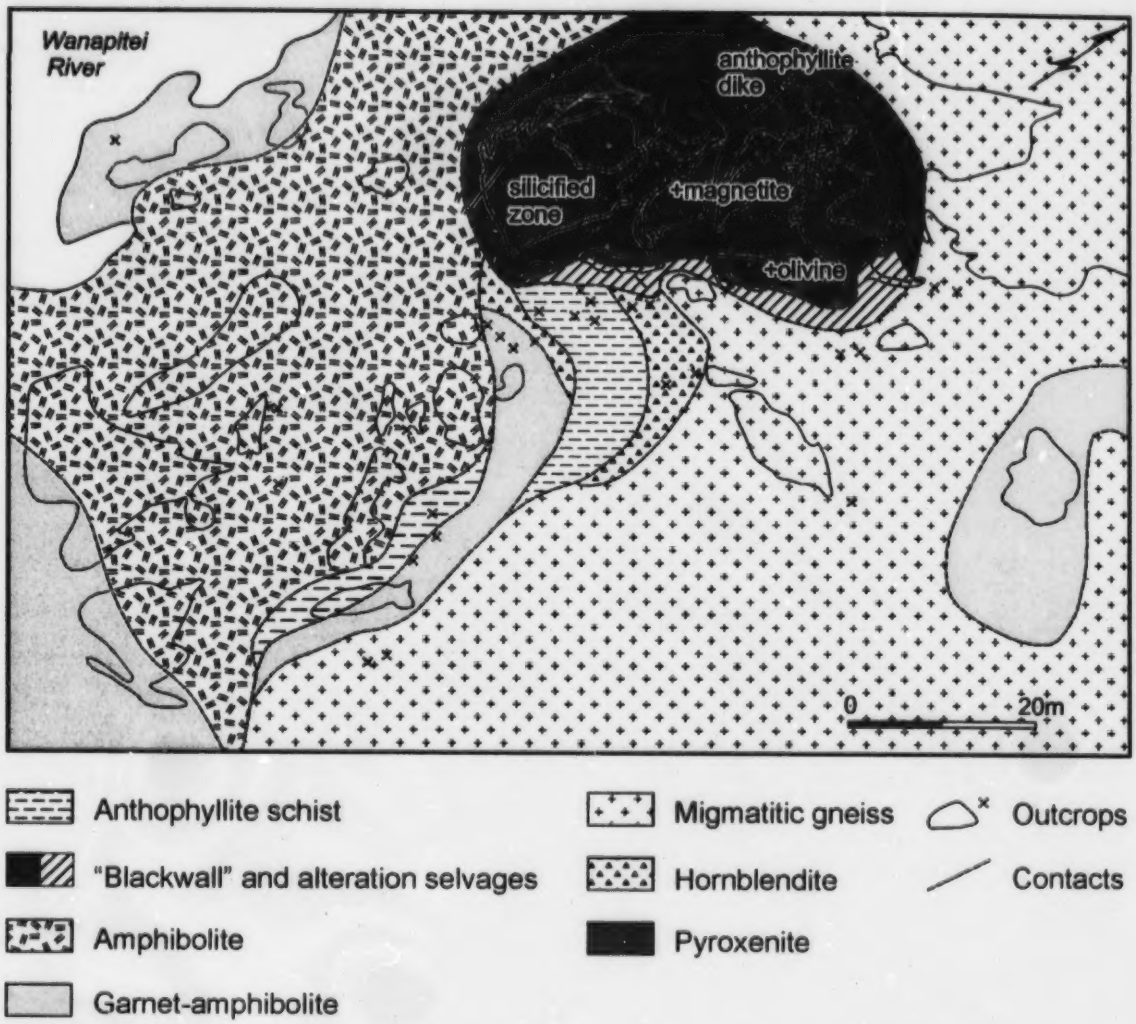


Figure 21. Simplified geological map of the "Stinson Body A" orthopyroxene hornblendite body studied by Hubbard (1998).

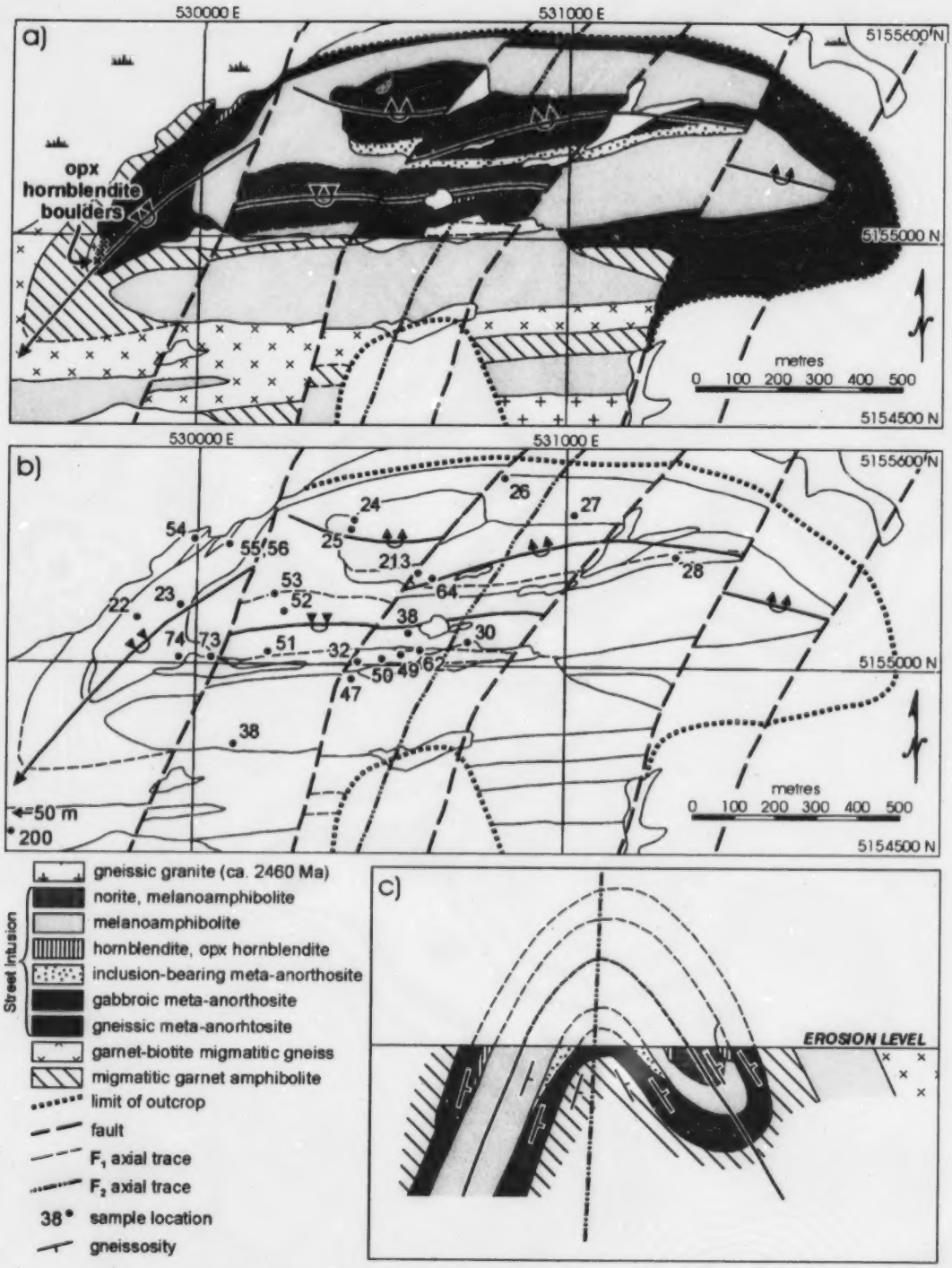


Figure 22. **a)** Geological map of the Street anorthositic metagabbro body. **b)** Location of assay samples from the Street anorthositic metagabbro body. The prefix 96RME- and 98RME- in the sample numbers has been omitted for clarity. **c)** Inferred cross-section of the Street anorthositic metagabbro body showing the effects of folding on the body.

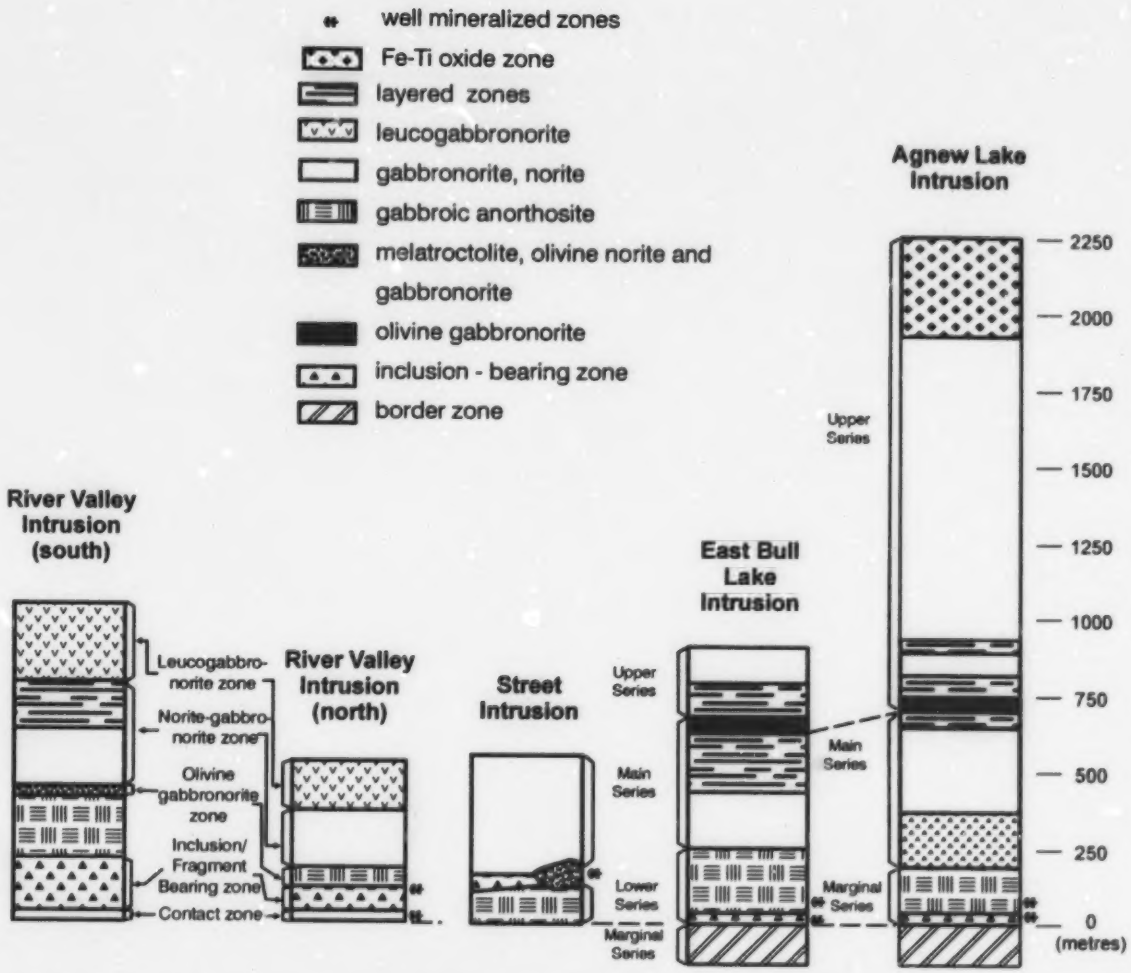


Figure 23. Generalized cross-sections for the Street metagabbro and the River Valley, East Bull Lake and Agnew Lake intrusions of the East Bull Lake intrusive suite. East Bull Lake section *modified from* Peck et al. (1995), Agnew Lake intrusion section *modified from* Vogel (1996), River Valley data *from* Easton (unpublished) and James et al. (2002).

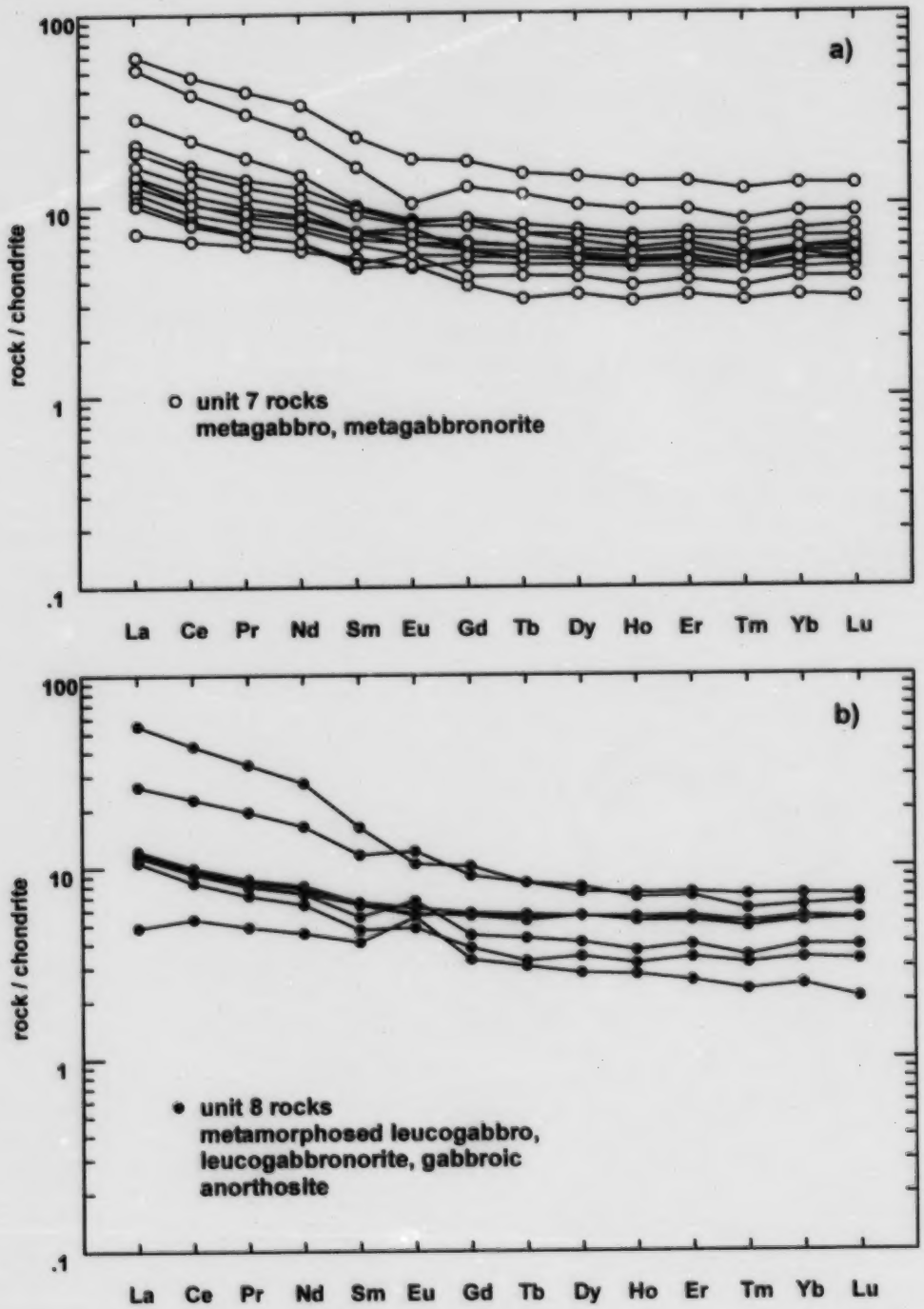


Figure 24. Chondrite-normalized rare earth element plots for East Bull Lake intrusive suire rocks from the Street metagabbro body in Street Township. Unit 7 (more mafic) rocks are shown in the upper plot, unit 8 (more felsic) rocks are shown in the lower plot.

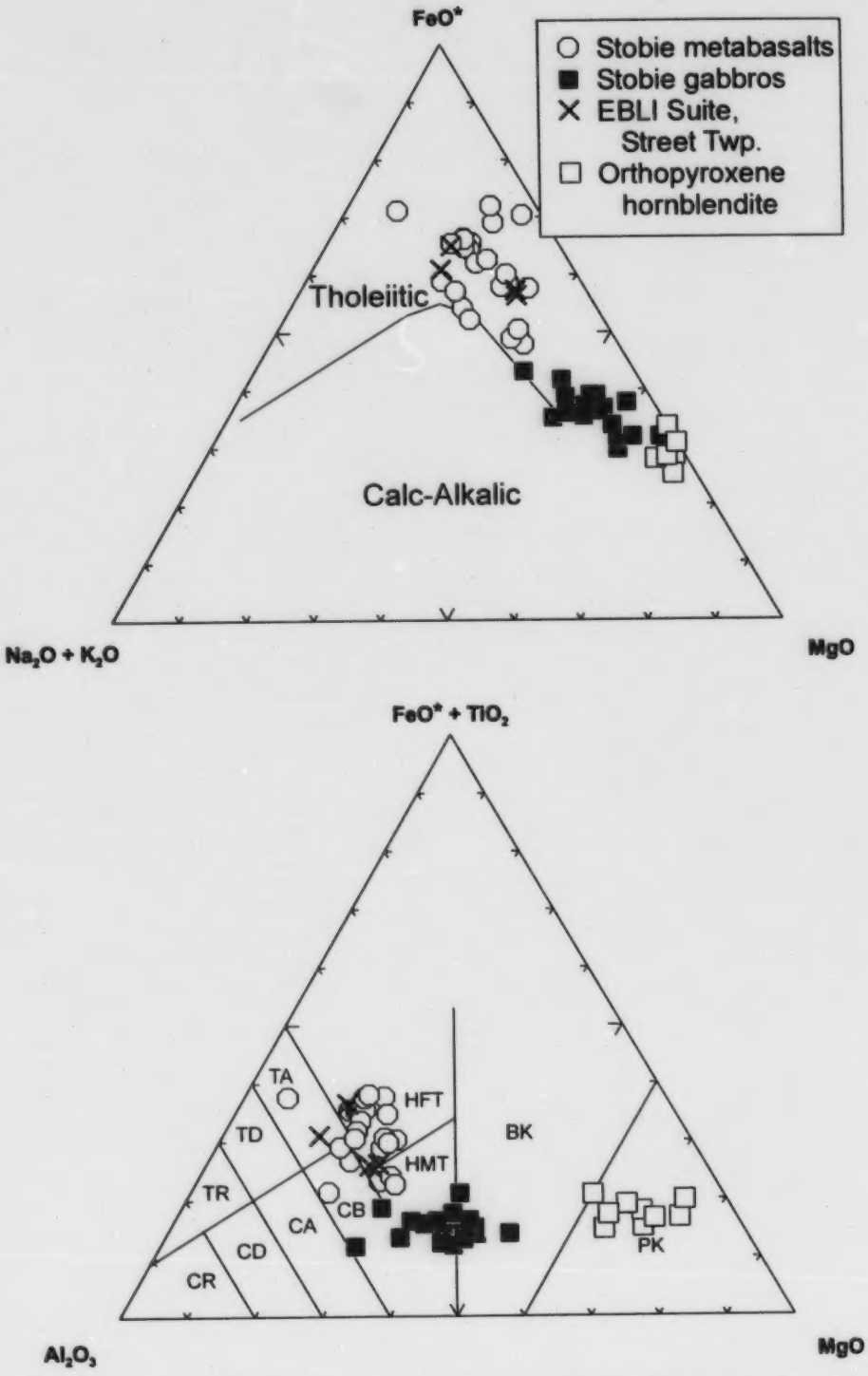


Figure 25. AFM (upper) and Jensen (lower) diagrams for Stobie Formation metabasalts. Data for Stobie Formation gabbros from Johns (1996). Data for East Bull Lake intrusive suite rocks are also shown.

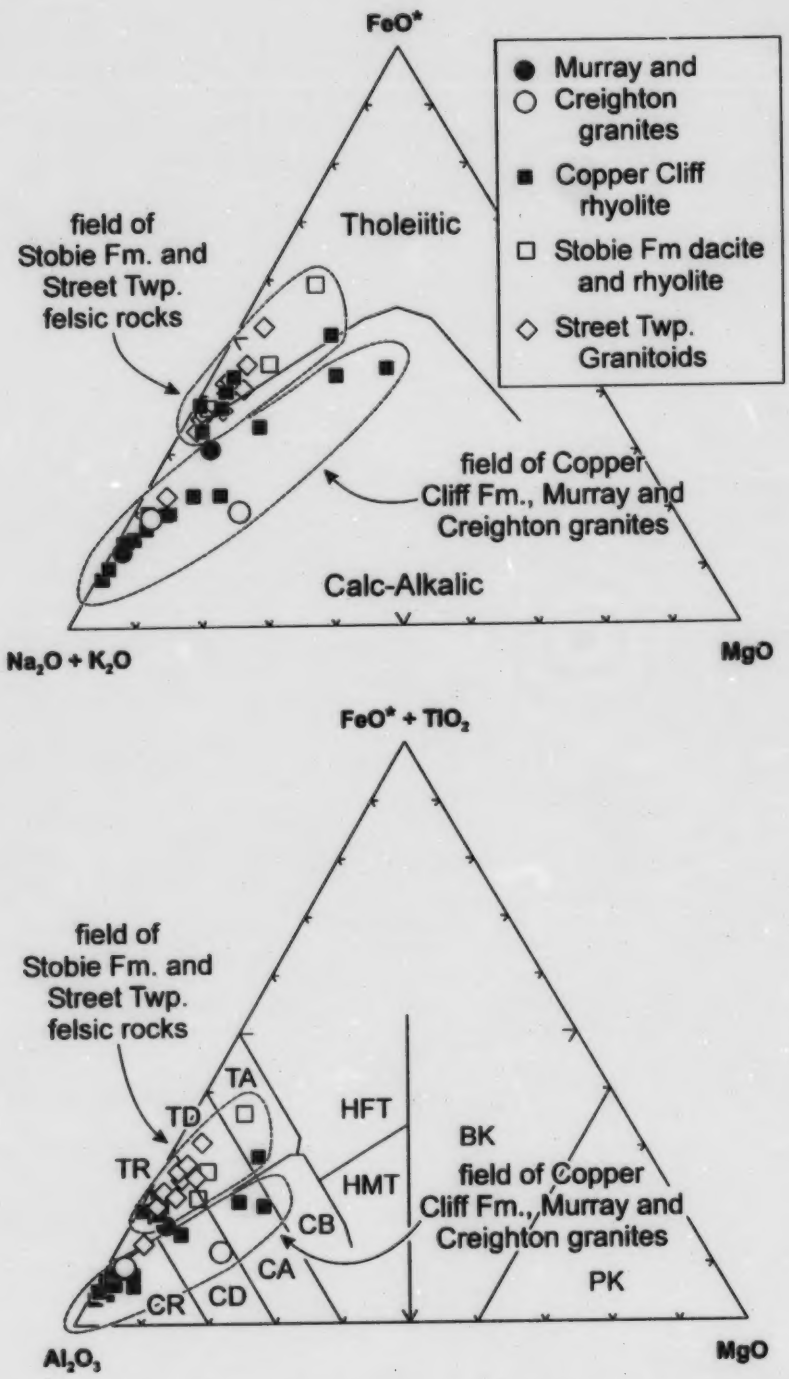


Figure 26. AFM (upper) and Jensen (lower) diagrams for felsic metavolcanic rocks of the Stobie Formation from Sudbury and Street Township, as well as data for the Street Township granitoids, the Copper Cliff Formation, and the Murray and Creighton granites. Note the felsic rocks fall into two groups. One group plots in the tholeiite field on both plots and consists of the Stobie Formation volcanic rocks, the Street Township granitoids, and a limited number of Copper Cliff Formation volcanic rocks. The other group plots in the calc-alkalic field on both plots, and consists of the bulk of the Copper Cliff Formation and the Murray and Creighton granites. Copper Cliff, Murray and Creighton granite data *from* Innes (1977) and Johns (1996).

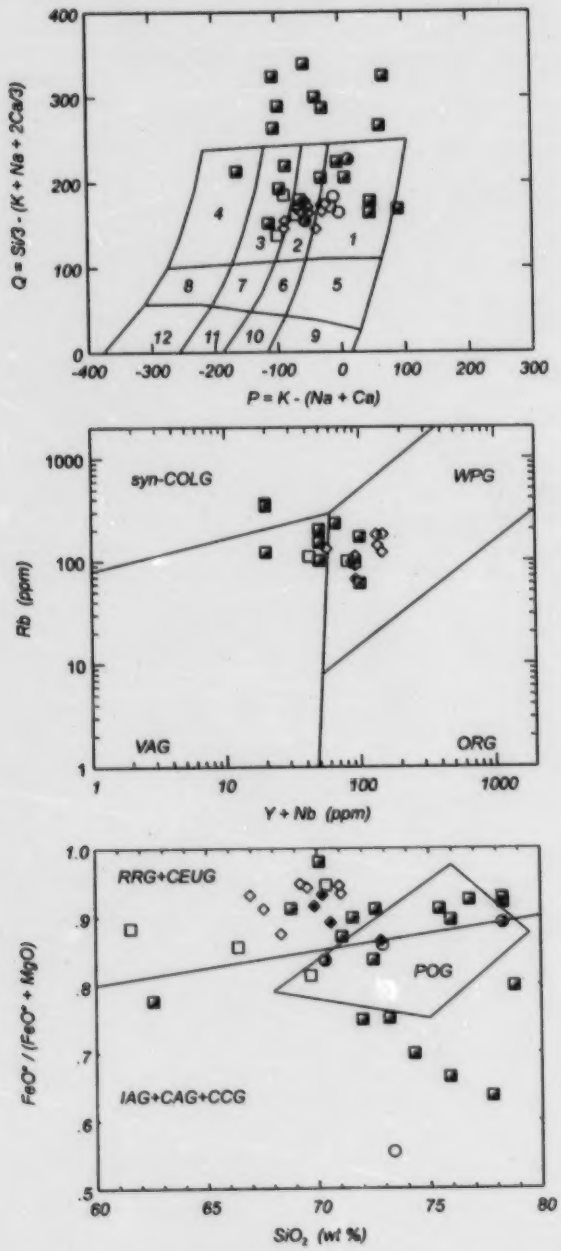


Figure 27. Granitoid classification plots of Debon and Le Fort (1983)(upper), Pearce, Harris and Tindle (1984)(middle) and Maniar and Piccoli (1989)(lower) for Huronian-age felsic intrusive and extrusive rocks using the same data as Figure 26. Symbols same as in Figure 26. Note in all plots the tight cluster of the Street Township granitoids. The Street Township granitoids classify as Within-Plate granites (WPG in middle plot) or Rift-Related granites (RRG in lower plot). Also note the scatter in the Copper Cliff Formation metarhyolites, which may result from alkali addition. Copper Cliff, Murray and Creighton granite data *from* Innes (1977) and Johns (1996). Abbreviations: Upper figure, 1 = syenogranite, 2 = monzogranite, 3 = granodiorite, 4 = tonalite. Middle figure, VAG = volcanic-arc granite, syn-COLG = syn-collision granite, WPG = within-plate granite. Lower figure, RRG+CEUG = rift-related and contiental epeirogenic uplift granites, IAG+CAG+CCG = island-arc, continental-arc and continental-collision granites, POG = post-orogenic granites.

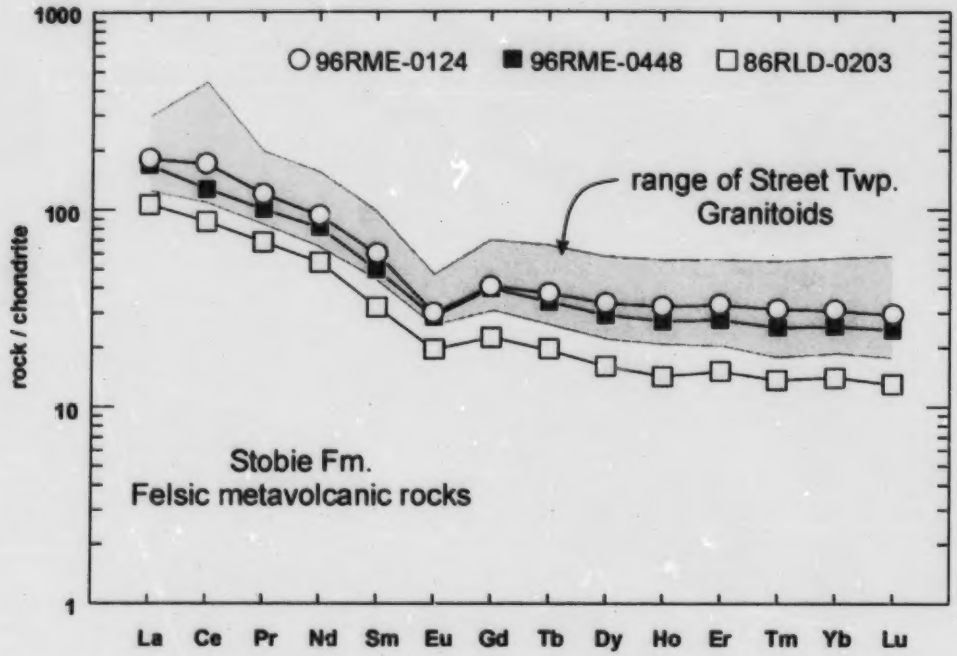


Figure 28. Chondrite-normalized rare earth element plots for felsic metavolcanic rocks of the Stobie Formation from Sudbury and Street Township, as well as the field for the Street Township granitoids. Sample 86RLD-0203 is from the Sudbury area, the other 2 samples are from Street Township. The latter overlap the range of the Street Township granitoids.

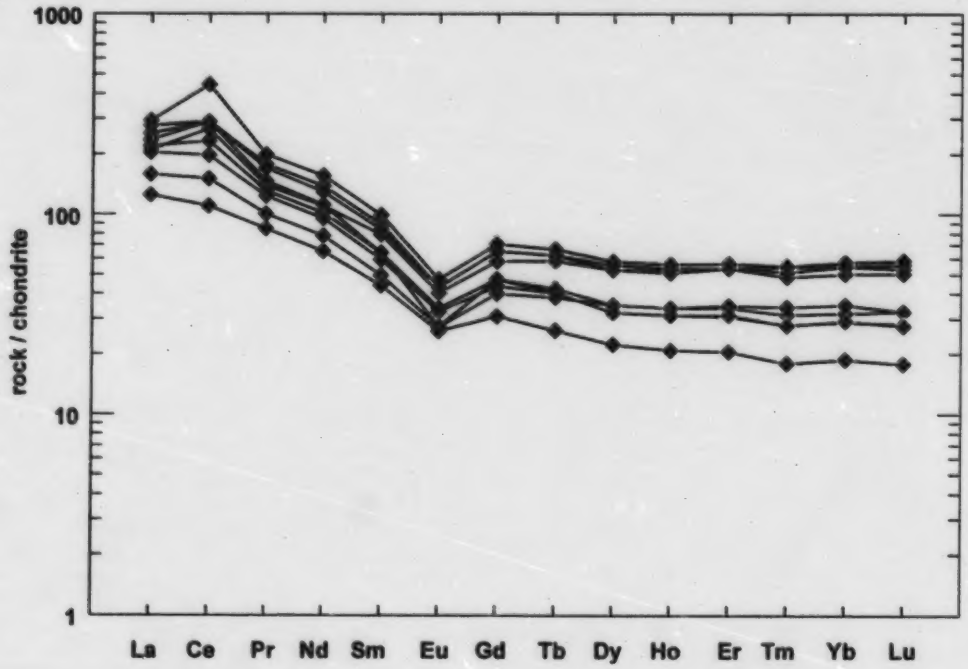


Figure 29. Chondrite-normalized rare earth element plots for 9 samples of granitoid rocks from Street Township. Samples 96RME-0602 and 96RME-0606 represent the two samples dated by Corfu and Easton (2000) (*see* Table 6).

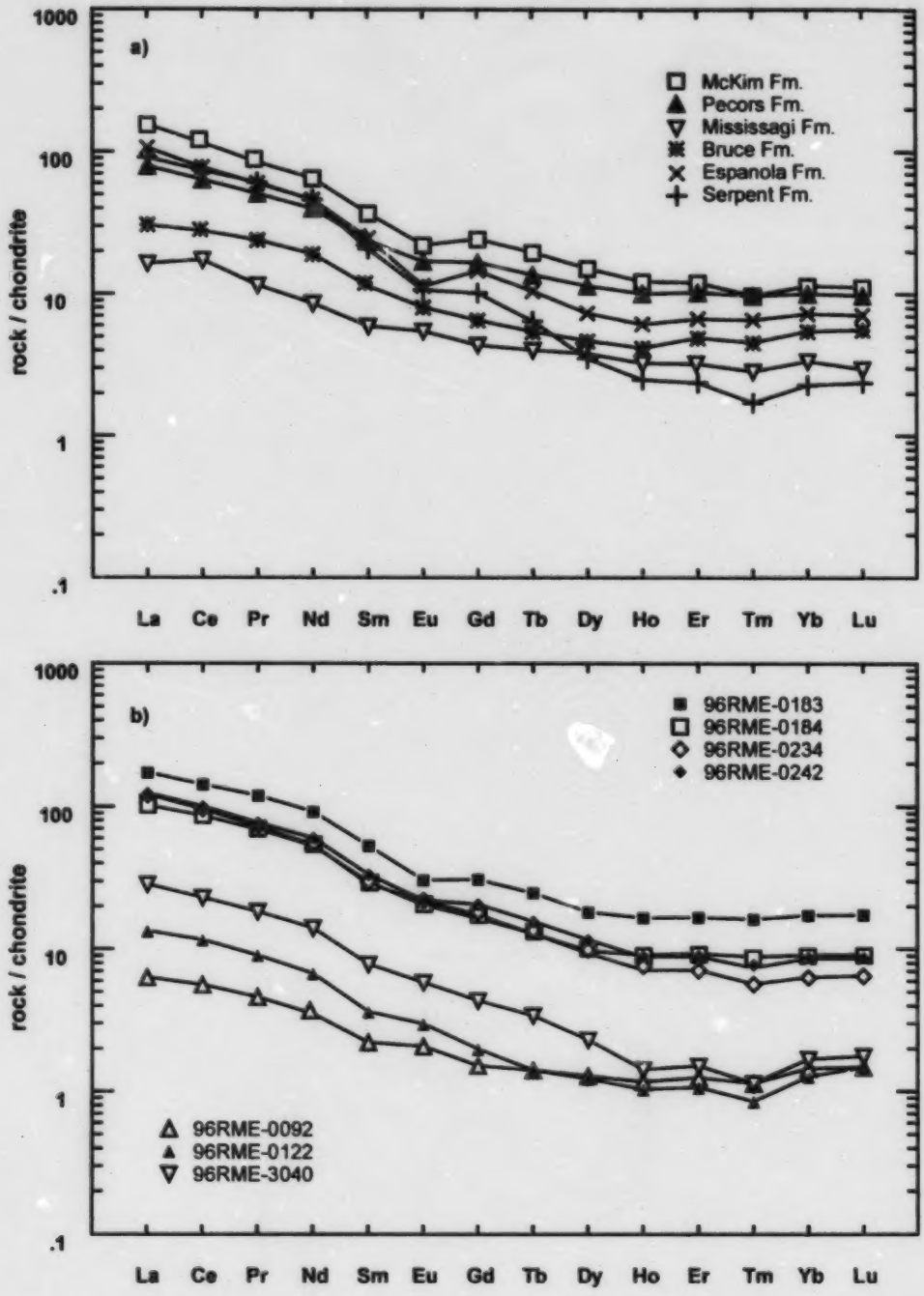


Figure 30. Chondrite-normalized rare earth element plot for Huronian Supergroup rocks in the Sudbury and Street Township areas. **a)** representative samples for the main Huronian Supergroup units found in Street Township. All samples were re-analyzed from pulps collected by Debicki (1990) (see Appendix 1). **b)** samples of Huronian Supergroup rocks from Street Township. All samples except 96RME-0092 are located south of the Grenville Front as defined in this study. Upper group of samples most likely were derived from the Pecors Formation, based on rare earth element and major element data. Lower group of samples most likely were derived from the Mississagi Formation.

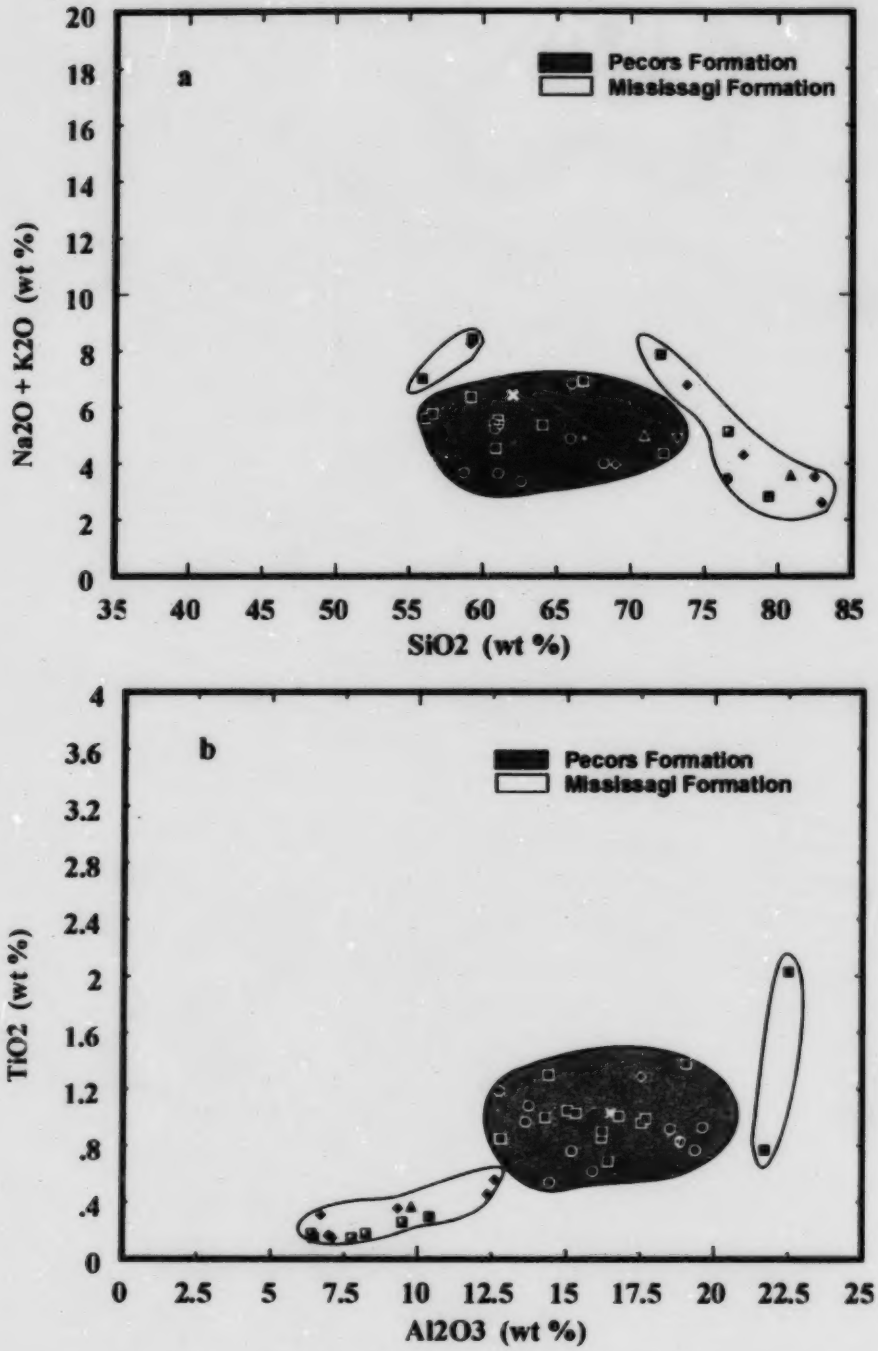


Figure 31. Major element chemistry of schist and paragneiss samples from the Timmins Creek area, showing overlap of samples from this study (data points) with the fields for the Pecors and Mississagi formations of the Huronian Supergroup. The two fields for the Mississage Formation represent shaly (moderate SiO_2, high Al_2O_3) and sandstone (high SiO_2, moderate Al_2O_3) samples respectively. *From* Murphy (2001).

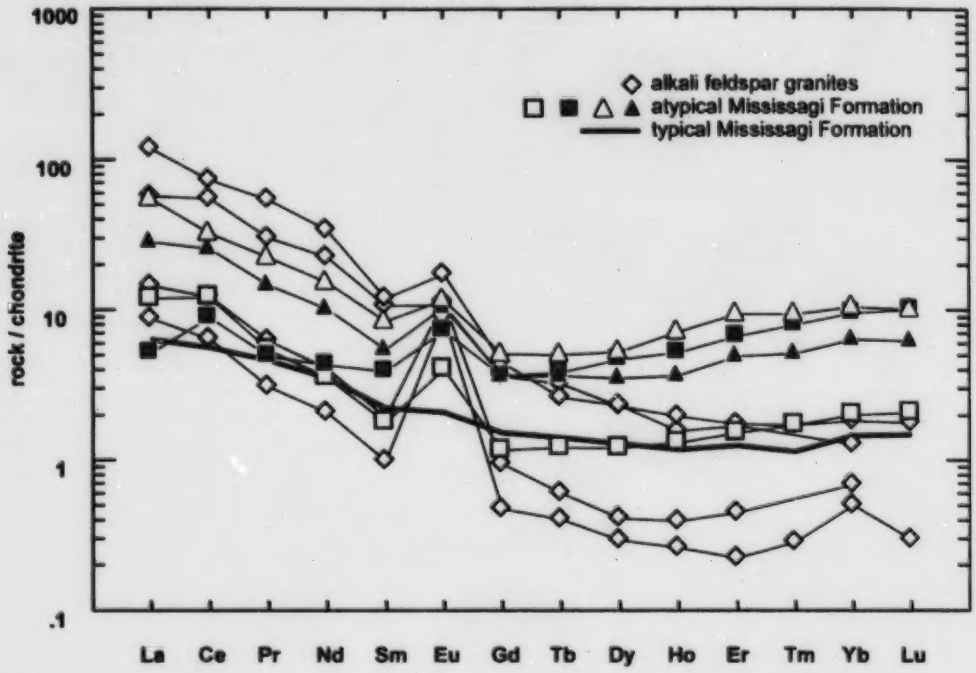


Figure 32. Chondrite-normalized rare-earth element plot for alkali feldspar granites from the River Valley area and atypical Mississagi Formation samples from the River Valley and Timmins Creek areas. Pattern for typical Mississagi Formation rocks is shown by the having black line. Note the positive Eu anomaly in both the granites and the atypical Mississagi Formation samples. See text for further details.

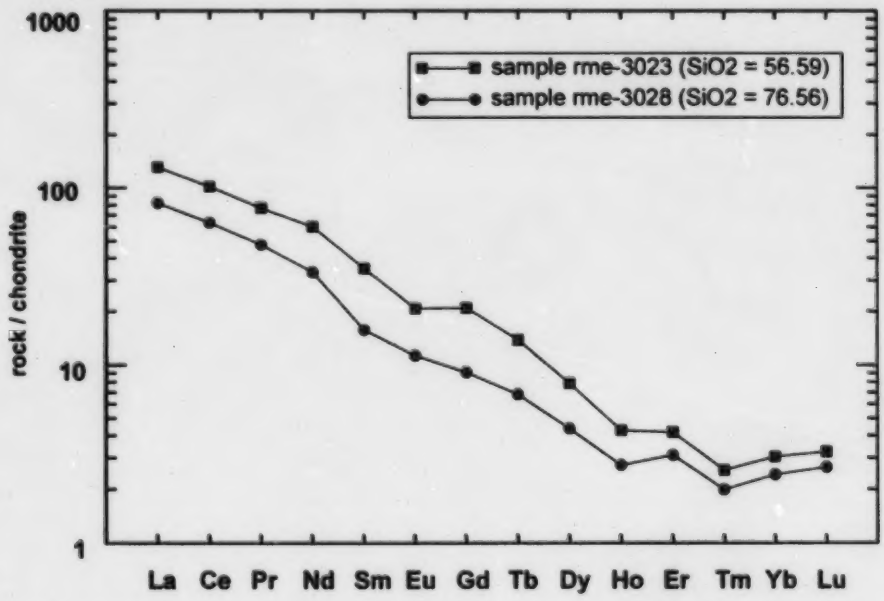


Figure 33. Chondrite-normalized rare earth element plots for 2 samples of biotite-garnet-muscovite schists (unit 3) located south of the Grenville Front boundary fault of Lumbers (1975). The steeply sloping rare earth element pattern is typical of Archean shales or FI type rhyolites, and suggests that these samples represent Archean metasedimentary or volcaniclastic rocks.

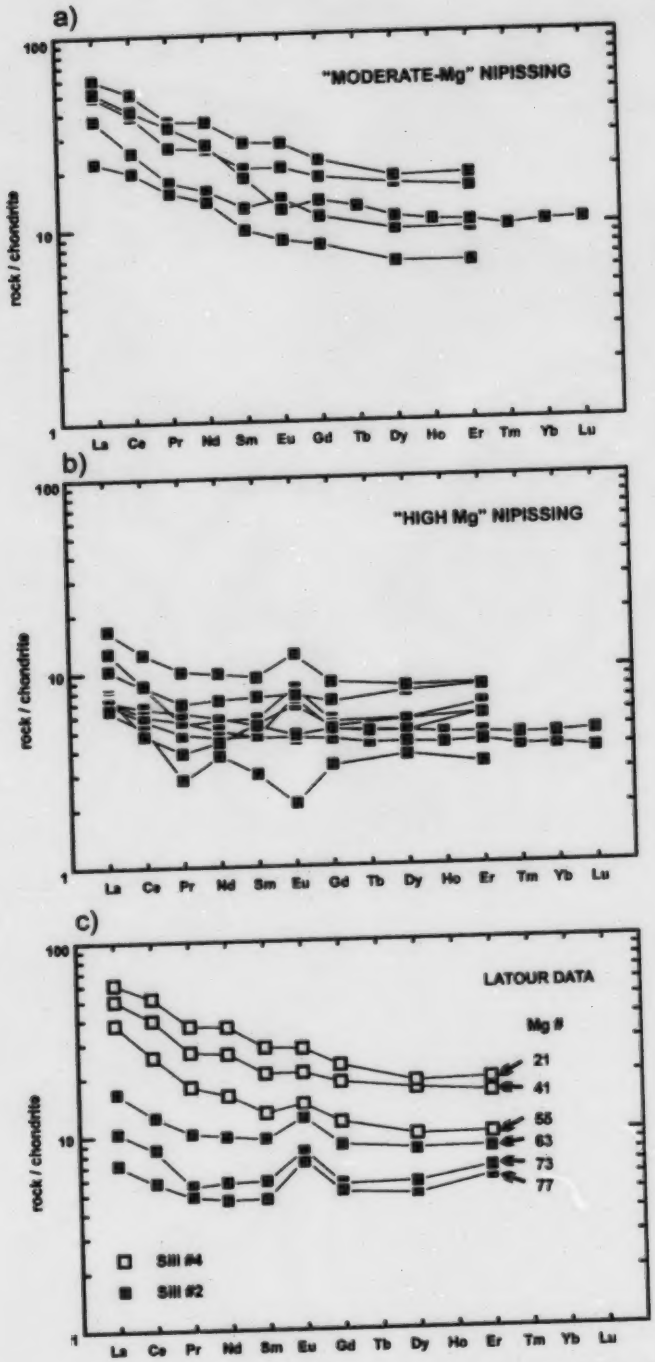


Figure 34. Chondrite-normalized rare-earth element plots for Nipissing gabbro sills from the Street Township area as well as for samples near Coniston studied by La Tour (1979). **a)** Moderate MgO Nipissing gabbro sills from locations both north and south of the Grenville Front in and around Street Township (sills with Mg numbers <55). **b)** High-MgO Nipissing gabbro sills from locations both north and south of the Grenville Front in and around Street Township (sills with Mg numbers >60). **c)** La Tour (1979) data for individual sills of both moderate MgO [open squares] and high-MgO [filled squares] types located immediately south of the Grenville Front. Mg numbers for individual samples shown for reference.

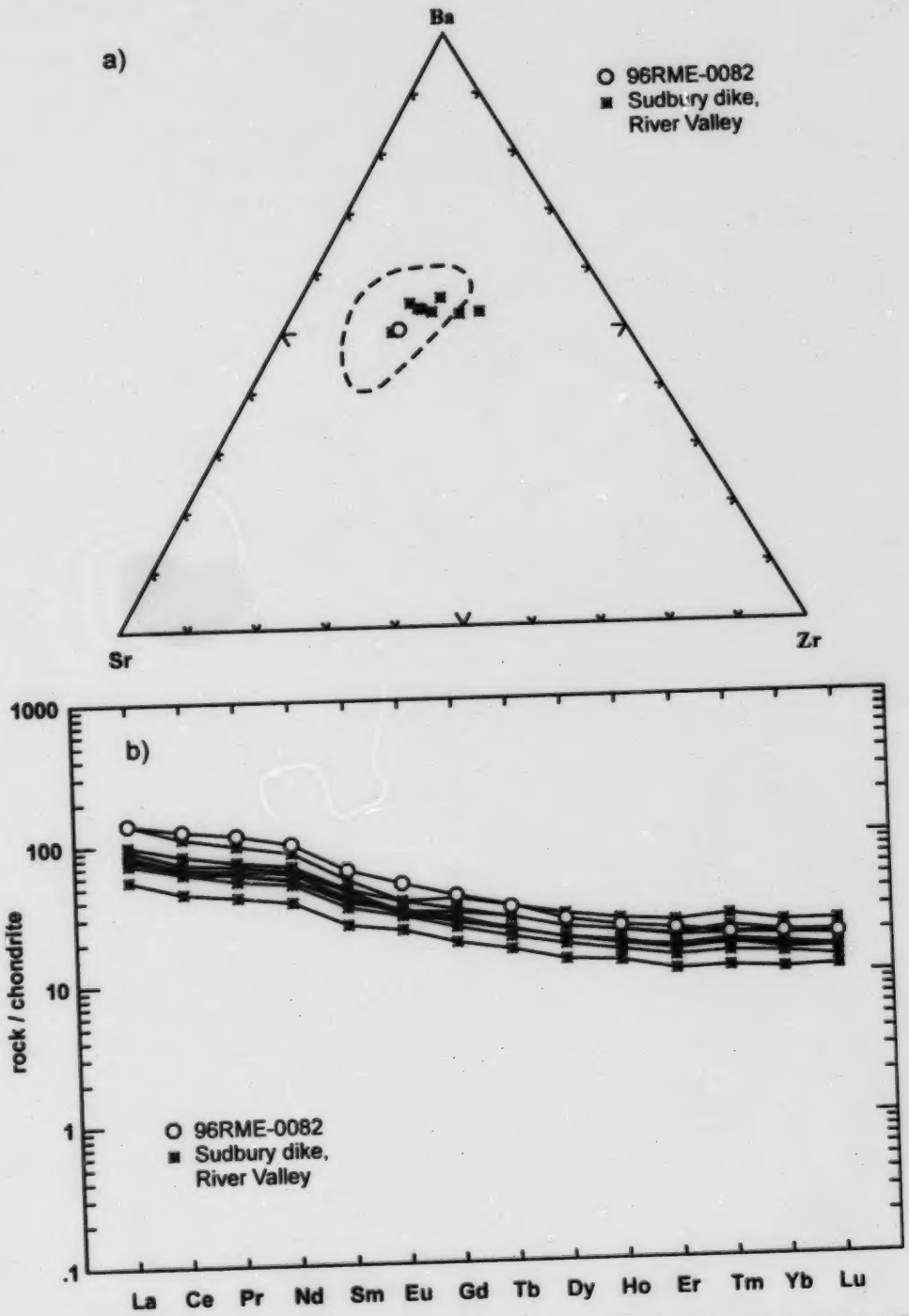


Figure 35. Geochemical data for Sudbury diabase dikes from the Street Township and River Valley areas. Sample 96RME-0082 is the only sample from within Street Township. **a)** Sr-Ba-Zr plot (*after* Bethune 1993, Ketchum and Davidson 2000). Note that the samples plot in the field for the Sudbury diabase field. Samples of most other dike swarms in Ontario would plot in the lower (Ba-poor) part of the dagram. **b)** Chondrite-normalized rare-earth element plot.

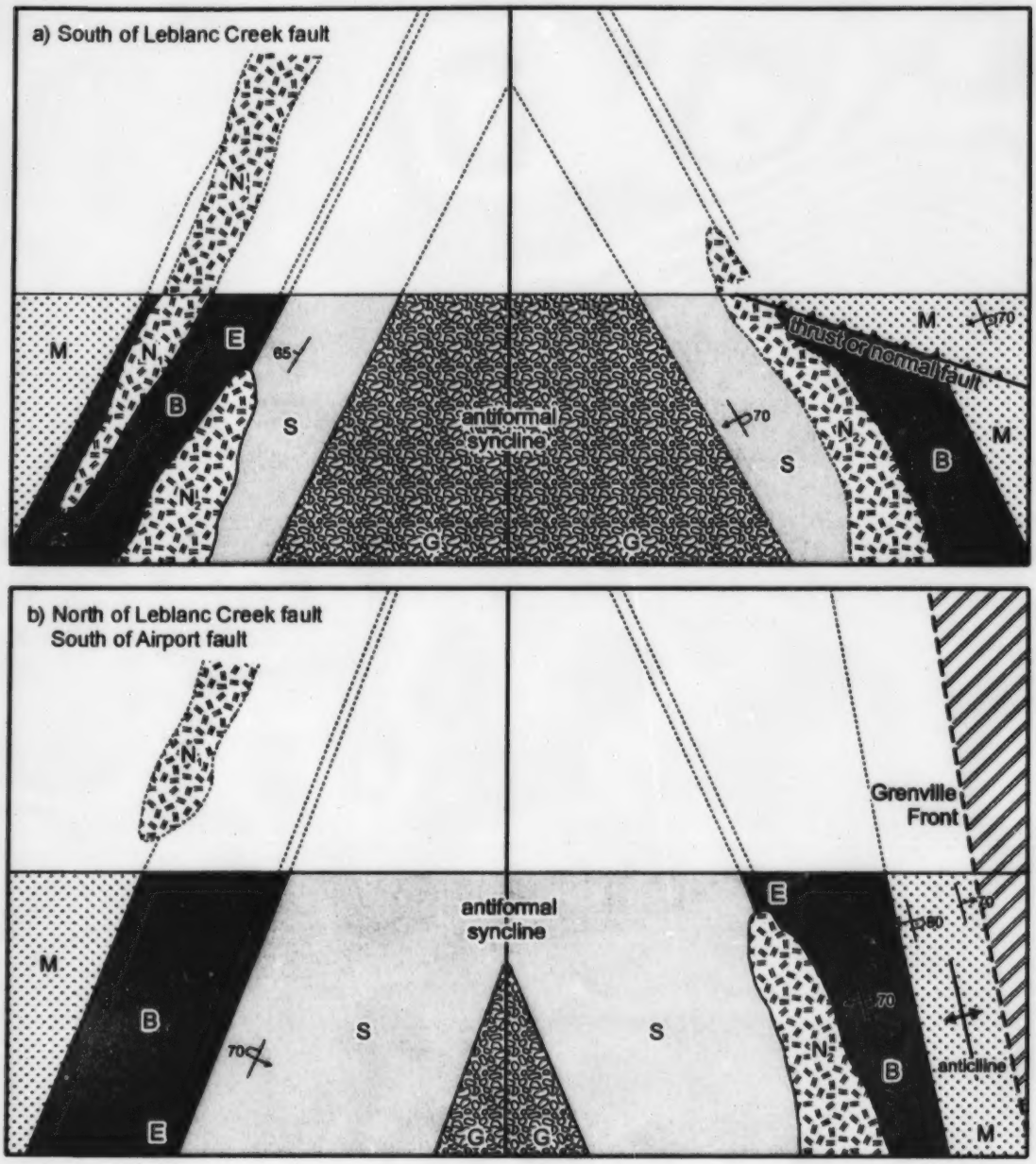


Figure 36. East–west located cross-sections for the Southern Province in western Street Township, illustrating the folding relationships between the main rock units.

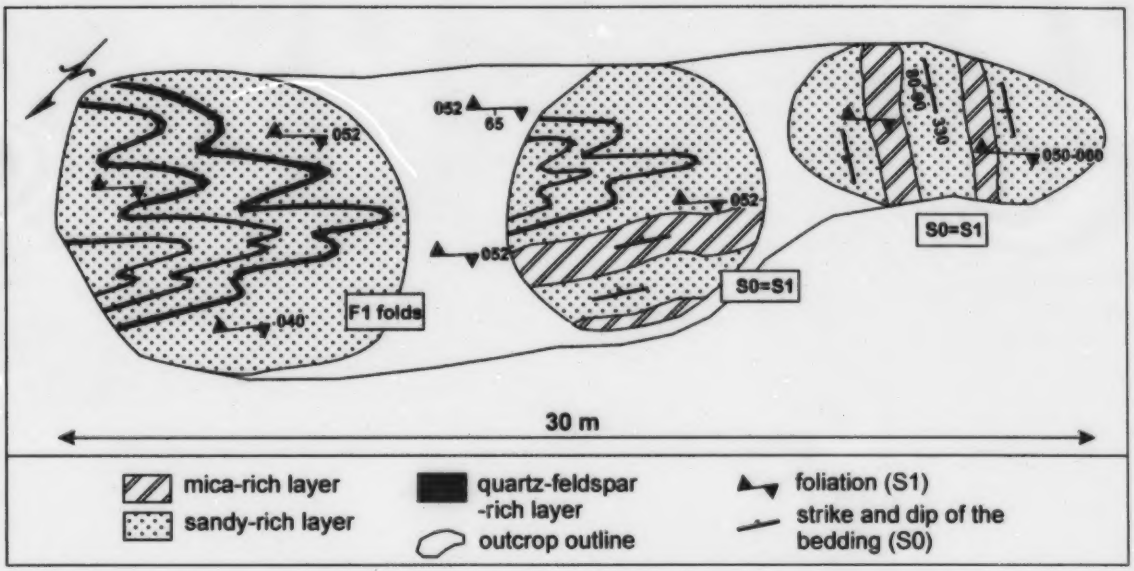


Figure 37. Relationship between bedding (S_0) and foliation (S_1) in the area between the Ess Creek fault and the Grenville Front boundary fault of Lumbers (1973), Timmins Creek area. Figure *from* Murphy (1999).

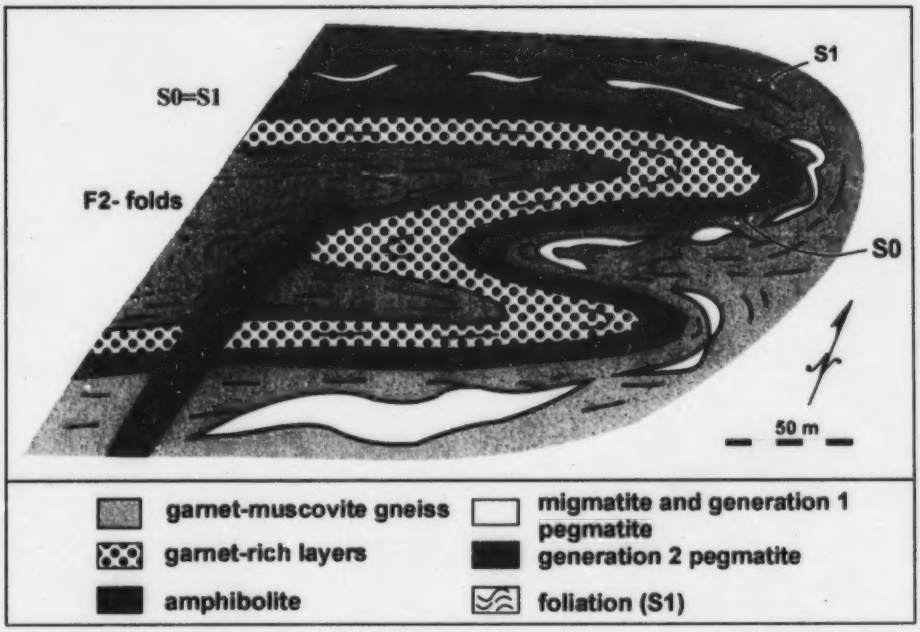


Figure 38. Relationship between bedding F_1 and F_2 folds immediately south of the Grenville Front boundary fault of Lumbers (1973) in the Timmins Creek area. Figure *from* Murphy (1999).

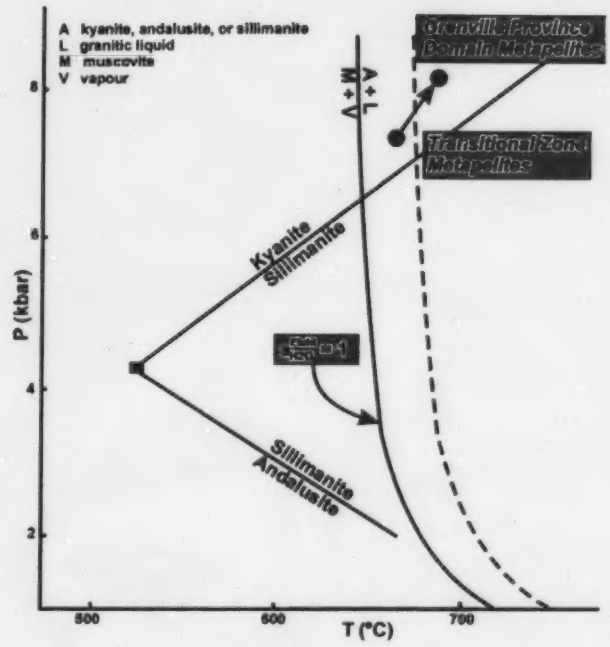


Figure 39. Simplified petrogenetic grid for the Street Township area, showing the location of Timmins Creek samples in *P–T* space, as well as the change in *P–T* for metapelites from the "Transitional Zone" located between the Ess Creek fault and the Grenville Front boundary fault and those located south of the Grenville Front boundary fault. Dashed line is the estimated position of the melting curve for muscovite + quartz. The diagram is simplified *from* Carmichael (1978). *From* Murphy (1999, 2001).

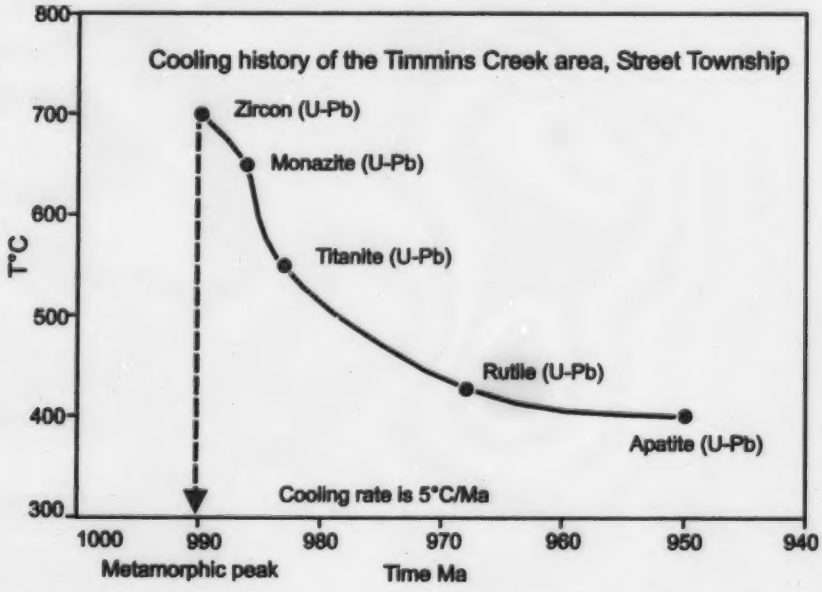


Figure 40. Temperature–time history curve for the Timmins Creek area, based on work by Corfu and Easton (2001). *From* Murphy (1999, 2001).

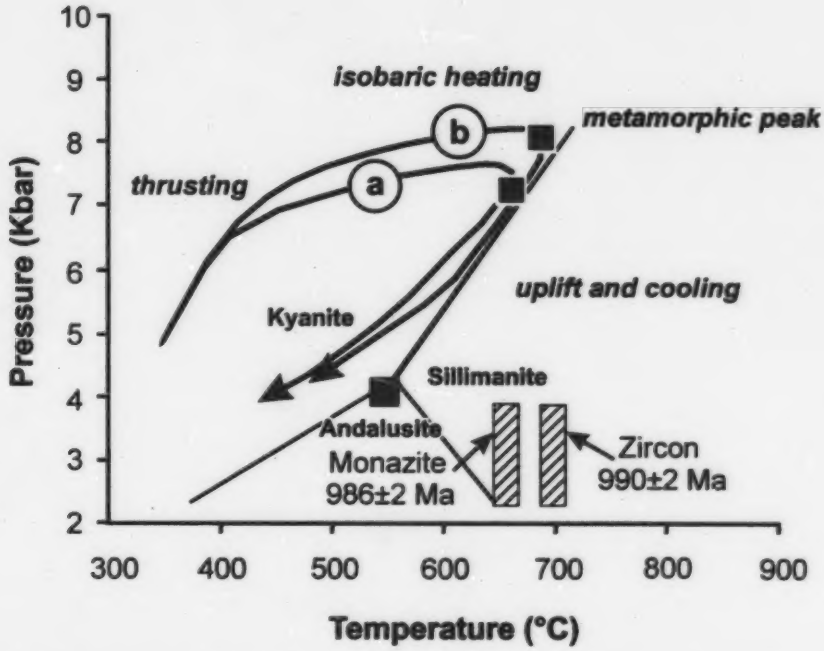


Figure 41. Generalized pressure-temperature-time (*P–T–t*) paths for the Timmins Creek area: Point (a) is a sample from the "Transitional Zone" present between the Ess Creek fault and the Grenville Front boundary fault, point (b) is from south of the Grenville Front boundary fault. *From* Murphy (1999, 2001).

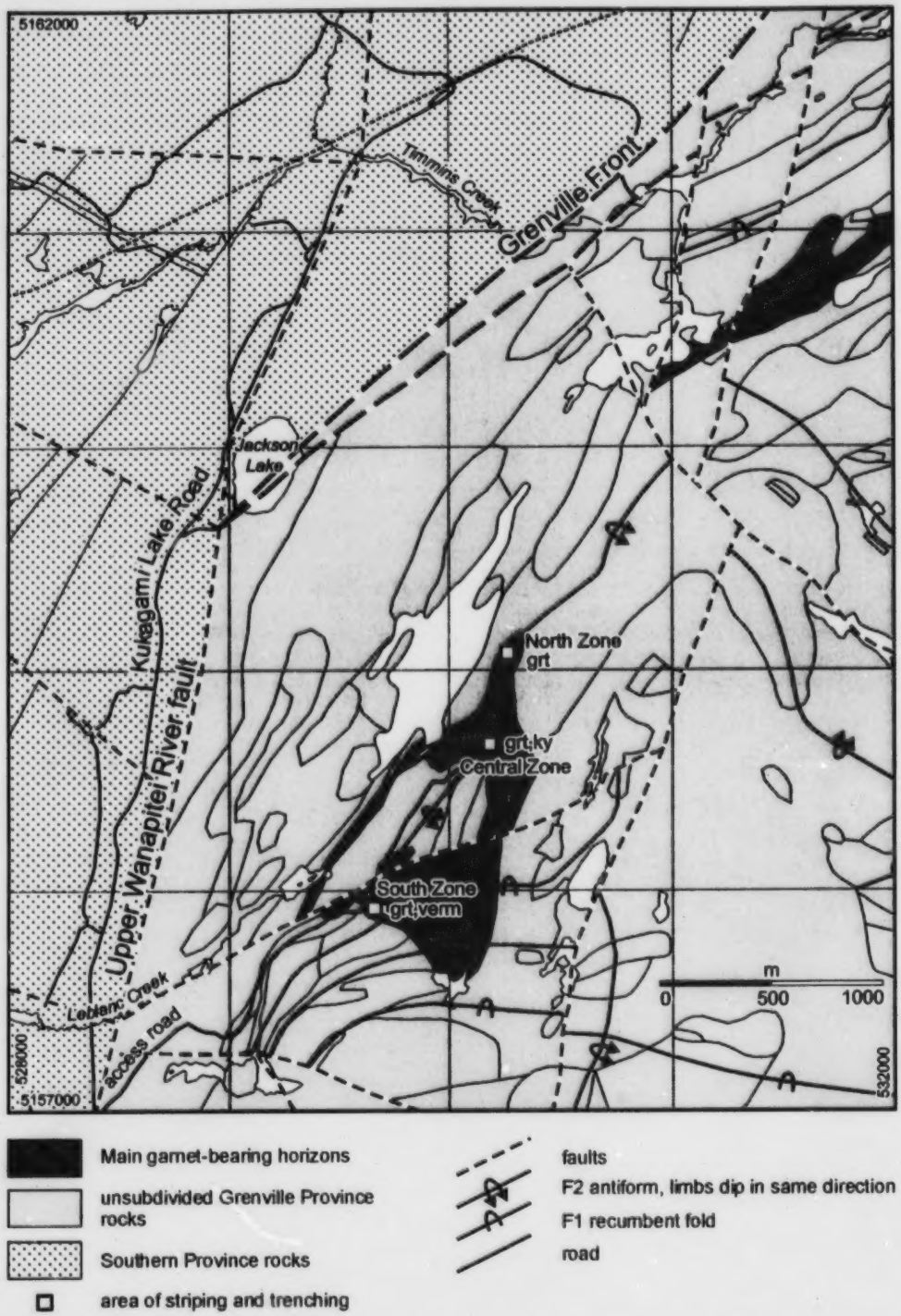


Figure 42. Geological sketch map showing the location of the main stripped and quarried areas of the Ecosource Garnet Inc. property, central Street Township. Geology simplified from Map. P.3427, back pocket. Abbreviations: grt = garnet; ky = kyanite; verm = vermiculite.

Photo 1. Photograph showing heterogenity within mafic gneiss of unit 1 on an outcrop scale. Garnet amphibolite with large garnet grains is present beneath the hammer in the lower left corner of the photograph. It is overlain by a thin, fine-grained dark layer of garnet poor amphibolite. Further right, migmatitic garnet amphibolite typical of unit 1 is present. Hammer handle is 30 cm long. Station 97RME-0319. UTM 529630E 5155795N.

Photo 2. Garnet amphibolite of unit 1e showing potential relict pillows. Hammer handle is 30 cm long. Station 97RME-0043 & 96RME-3028. UTM 531950E 5161595N.

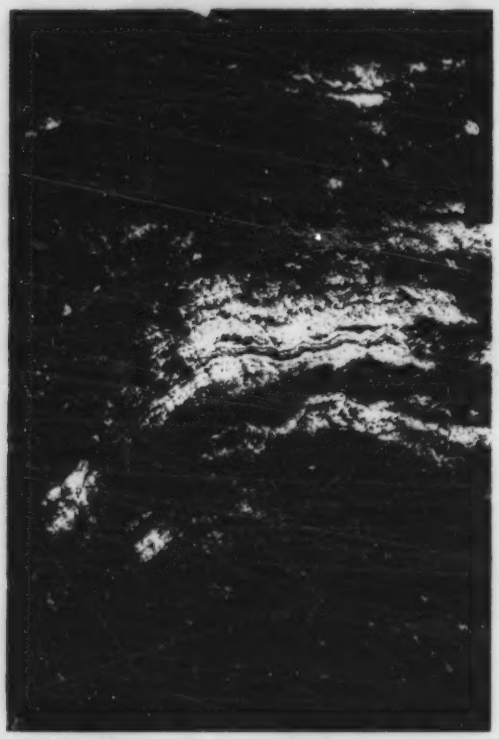


Photo 3. Compositional layering within quartzose gneisses of unit 3. Hammer handle is 30 cm long. Station 96RME-0115. UTM 529977E 5158650N.

Photo 4. Garnet amphibolite of unit 4 showing typical surreitic (pod-like leucosome) migmatitic texture. Hammer handle is 30 cm long. Station 95RME-0157. UTM 530709E 5159863N.

Photo 5. Orthopyroxene hornblendite of unit 6. Large orthopyroxene crystals occur in a matrix of fine-grained accicular amphibole. Hammer handle is 30 cm long. Station 96RME-0390, "Stinston body A". UTM 525120E 5153425N.

Photo 6. Black weathering medium-grained melanoamphibolite of unit 7. Note layering in outcrop; this layering may be cryptic layering and not tectonic layering. Hammer handle is 35 cm long. Station 96RME-0200, UTM 529378E 5154441N.

Photo 7. Interlayered gneissic anorthositic gabbro (unit 8) and gneissic melagabbro (unit 7) within the Street metagabbro body. Hammer handle is 35 cm long. Station 96RME-0212 and 98RME-0066. UTM 530821E 5155183N.

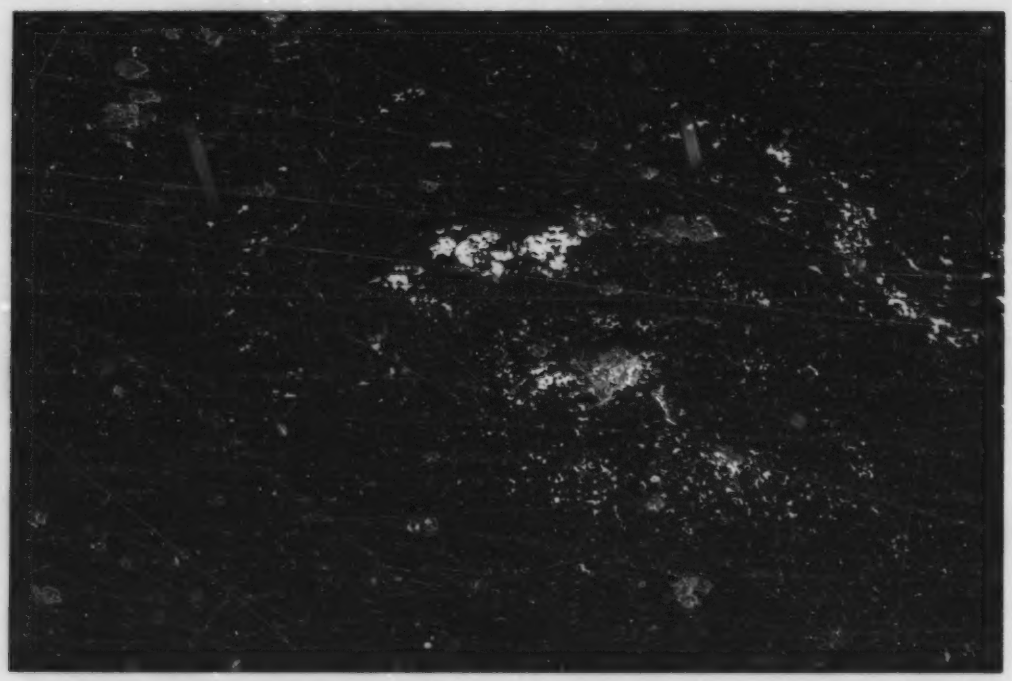


Photo 8. Large block of gabbroic anorthosite (light coloured rock immediately below hammer) incorporated in migmatitic granitic gneiss of unit 9 in southern Street Township. Hammer handle is 30 cm long. Station 96RME-0060. UTM 529000E 5153400N.

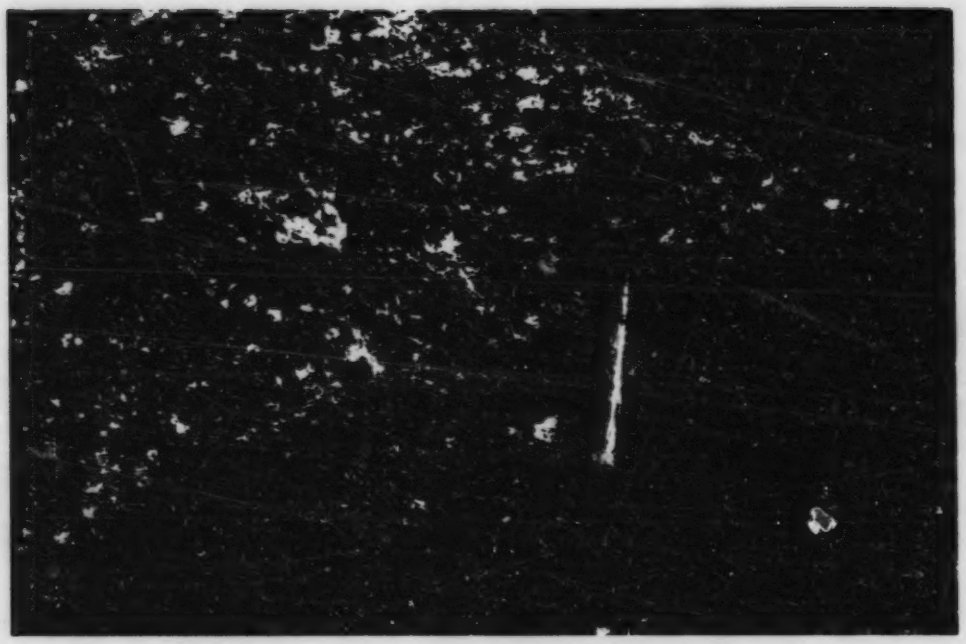


Photo 9. Coarse grained pegmatite vein to the left of the hammer intruding migmatitic granite gneiss (unit 9b). The main rock yields an age of $2475^{+25}/_{-10}$ Ma (*see* Table 6), the leucosome gives an age of 995±3 Ma (*see* Table 6), and the crosscutting pegmatite yields an age of 989±2 Ma (*see* Table 6). Hammer handle is 30 cm long. Station 96RME-0600. UTM 528006E 5154033N.

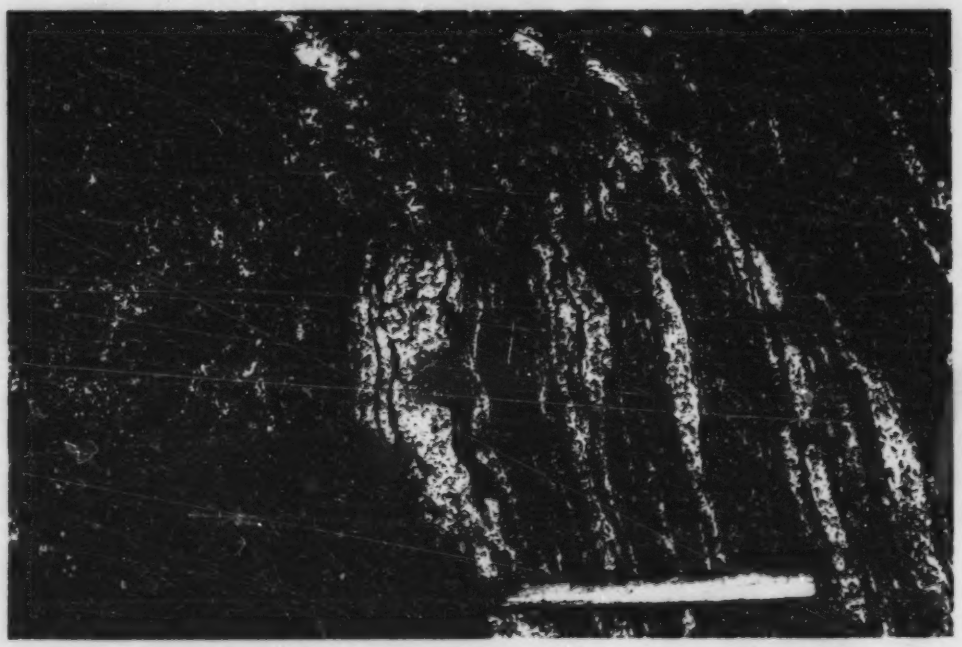


Photo 10. Migmatitic granite gneiss (unit 9c) showing earlier leucosome that is subconcordant to the regional fabric as well as later subconcordant leucosome (layer opposite hammer head) vertical crosscutting layer above hammer head. Hammer handle is 35 cm long. Station 96RME-0197. UTM 528925E 5154350N.

Photo 11. Compositional layering in garnet-biotite schist (unit 12b) in the Timmins Creek area. Outcrop islocated between the Ess Creek fault (Grenville Front) and the Grenville Front boundary fault of Lumbers (1973). Photo 9 showsthe higher grade equivalent of this rock south of the Grenville Front boundary fault. Chemistry suggests that this rock is a metamorphosed equivalent of the Pecors Formation, monazite from this outcrop yields a U/Pb age of 987±3 Ma (Table 6). Hammer handle is 30 cm long. Station 96RME-0234 and 96RME-3112. UTM 531930E 5162020N.

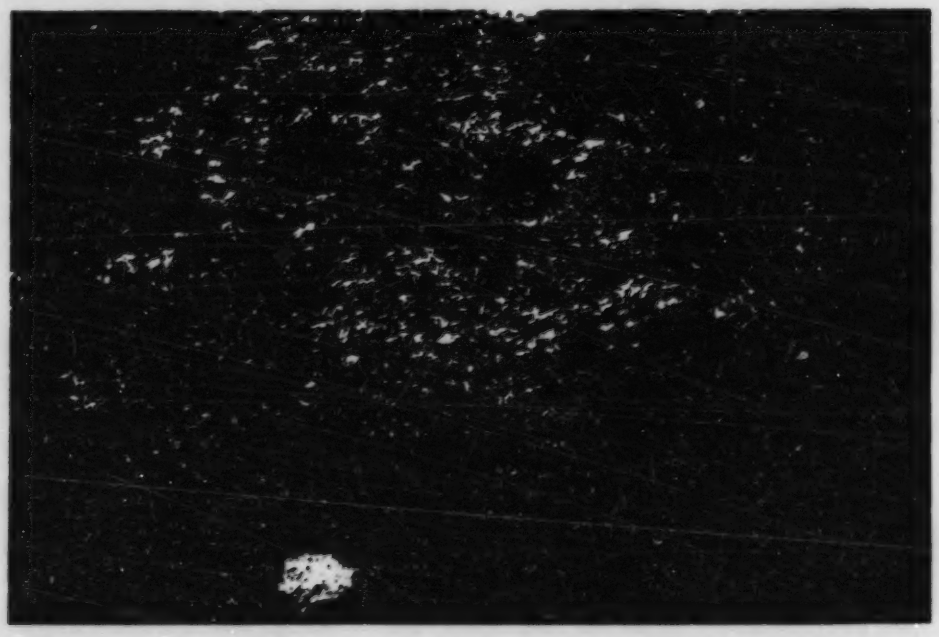


Photo 12. Gneissic layering within garnet-kyanite-biotite gneiss in the Timmins Creek area (unit 12d). Outcrop is located 100 m south of the Grenville Front boundary fault of Lumbers (1973). Chemistry suggests that this rock is a metamorphosed equivalent of the Pecors Formation, nearly identical to the lower grade equivalent rock shown in Photo 8. Monazite from this outcrop yields a U/Pb age of 989±2 Ma (Table 6). Hammer handle is 30 cm long. Station 96RME-0242. UTM 531900E 5161900N.

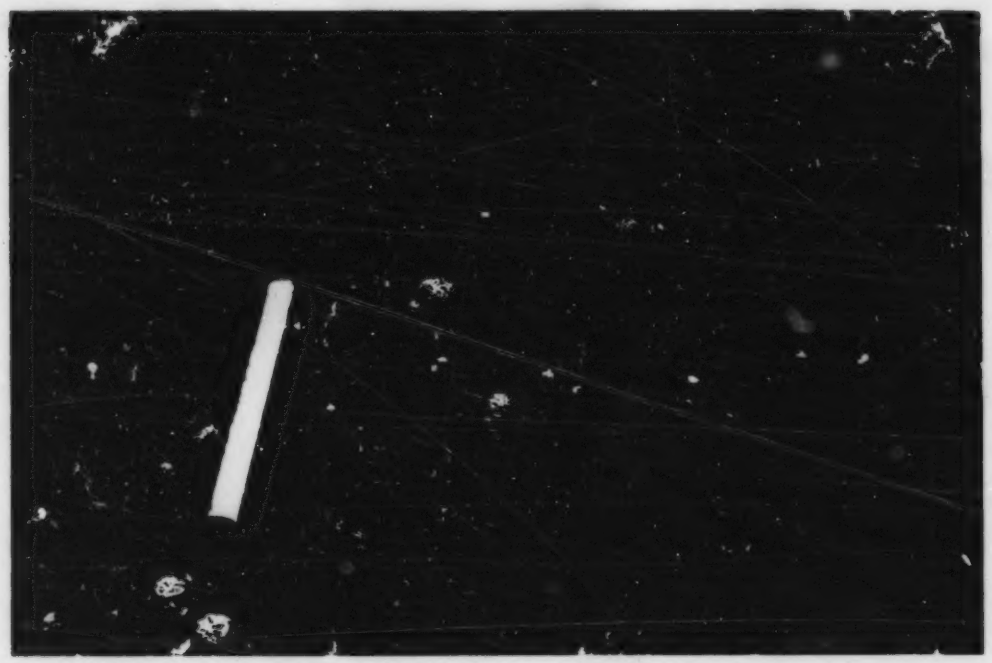


Photo 13. Reverse grading present in metawacke of the Mississagi or Pecors Formation (unit 13c). Coarse crystals by hammer head and handle tip are large kyanite grains developed in former pelitic beds. Intervening medium-grained layers are meta-arenite in composition. Hammer handle is 35 cm long. Station 96RME-0183. UTM 527529E 5154663N.

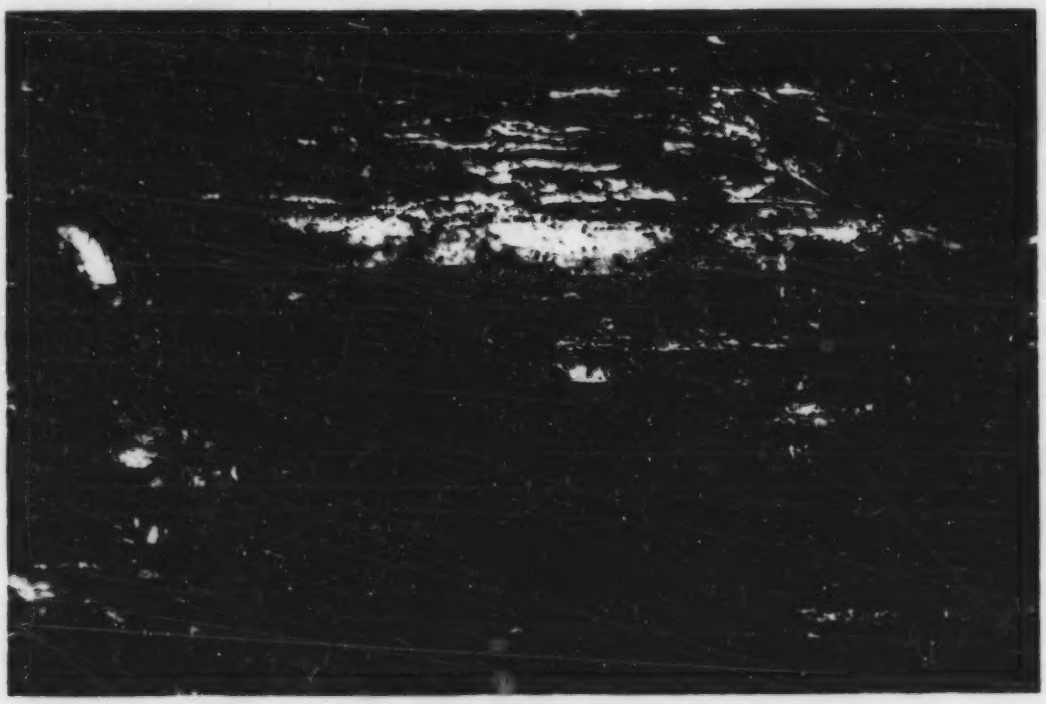


Photo 14. Espanola Formation siltstone (unit 15) exposed north of the Airport fault. Hammer head is 17.5 cm long. Station 96RME-0136. UTM 527169E 5162817N.

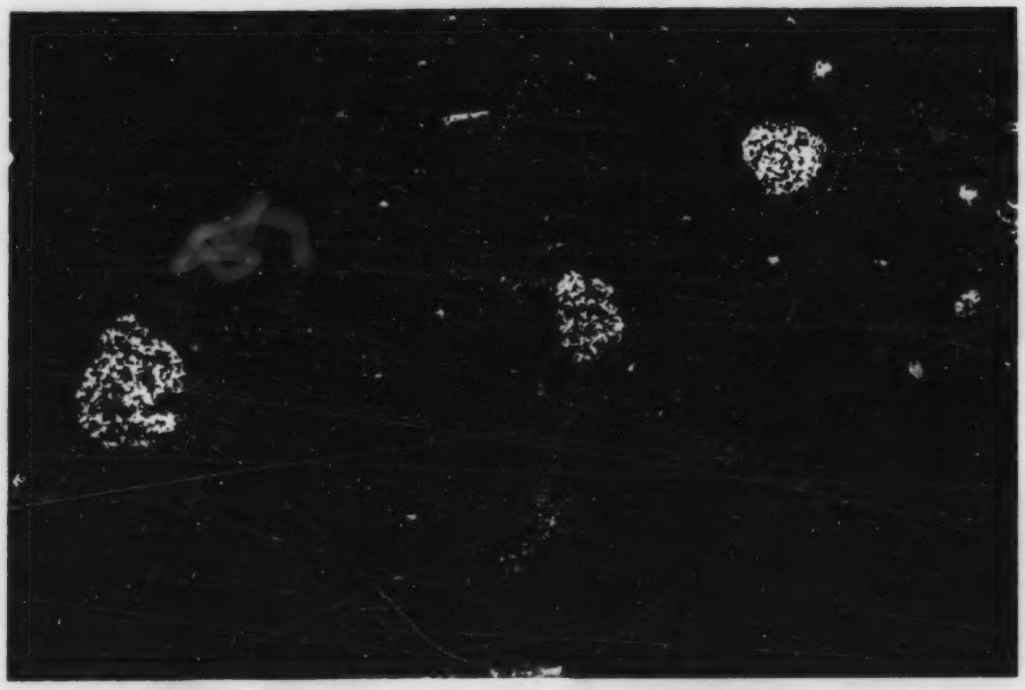


Photo 15. Gowganda Formation conglomerate (unit 17) exposed in west-central Street Township. Note the presence of 3 largish subrounded granitic clasts typical of the unit (white). Hammer handle at bottom of photo is 30 cm long. Station 96RME-0374. UTM 524880E 5157320N.

Photo 16. Sudbury breccia (unit 19) develeoped within Mississagi Formation arenite on the northeast shore of the Wanapitei River within the Southern Province in Street Township. Large rectangular block in centre of photograph is 50 cm across and 300 cm long. Station 96RME-0258. UTM 526440E 5155255N.

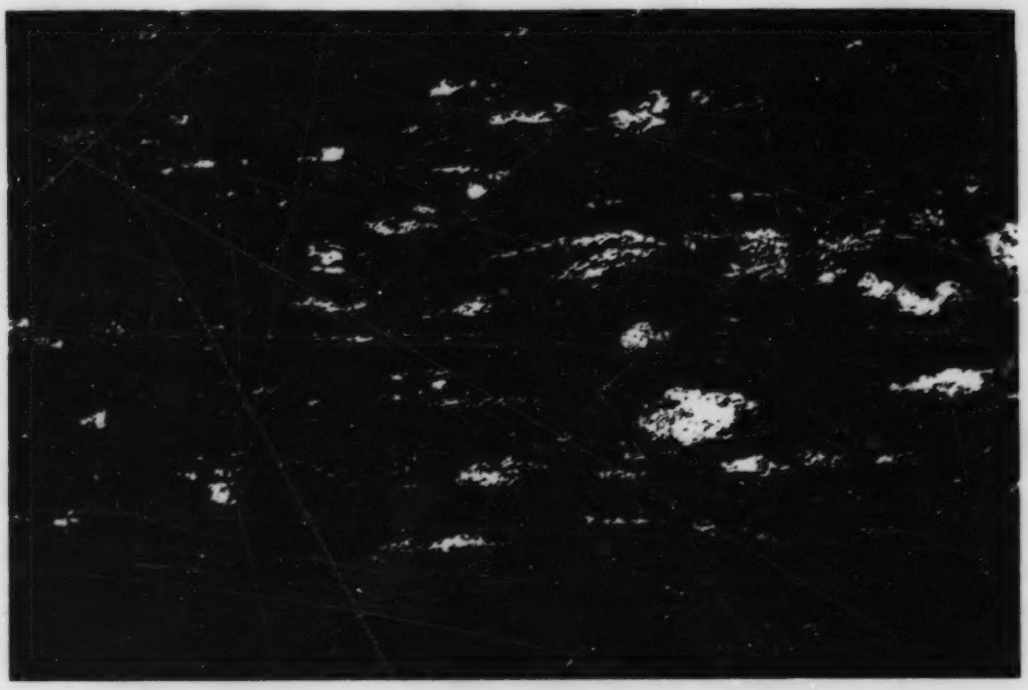


Photo 17. Mafic to intermediate migmatitic gneiss of unit 21, containing 2 generations of leucosome, one that is thin and regular, the other is boudinaged and irregular. Rocks of unit 21 commonly contain 5 to 15% biotite, which is not commonly present in mafic gneiss of unit 1. Hammer handle is 30 cm long. Station 95RME-0143. UTM 529000E 5157330N.

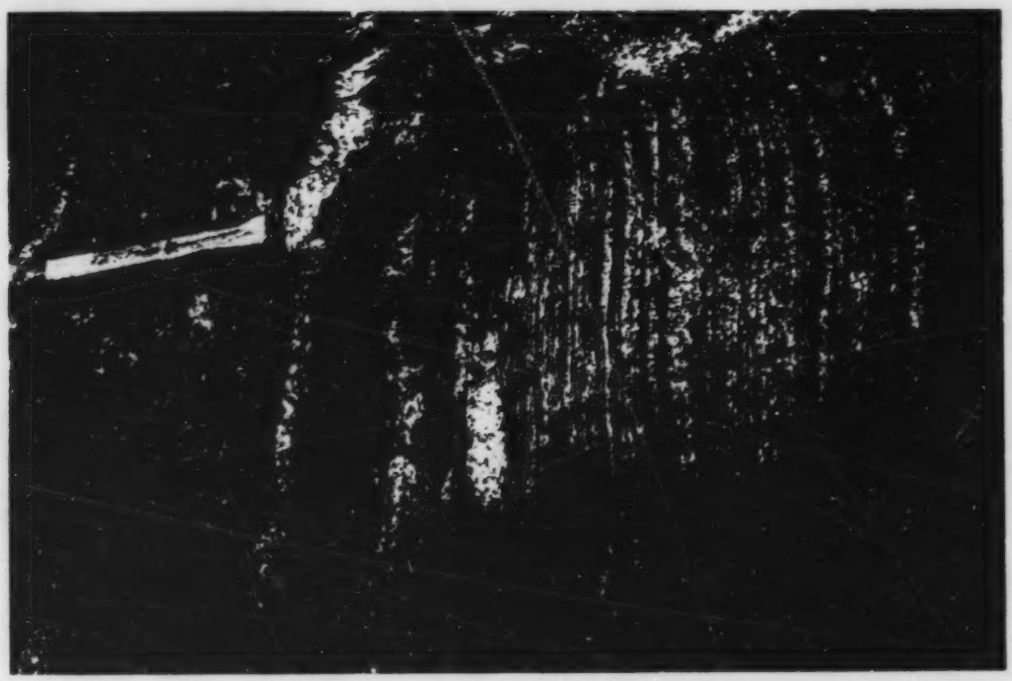


Photo 18. Intermediate to felsic migmatitic gneiss of unit 22c, containing 2 generations of leucosome and small garnets in both the mesosome and the leucosome. Hammer handle is 30 cm long. Station 96RME-0055. UTM 5269000E 5153750N.

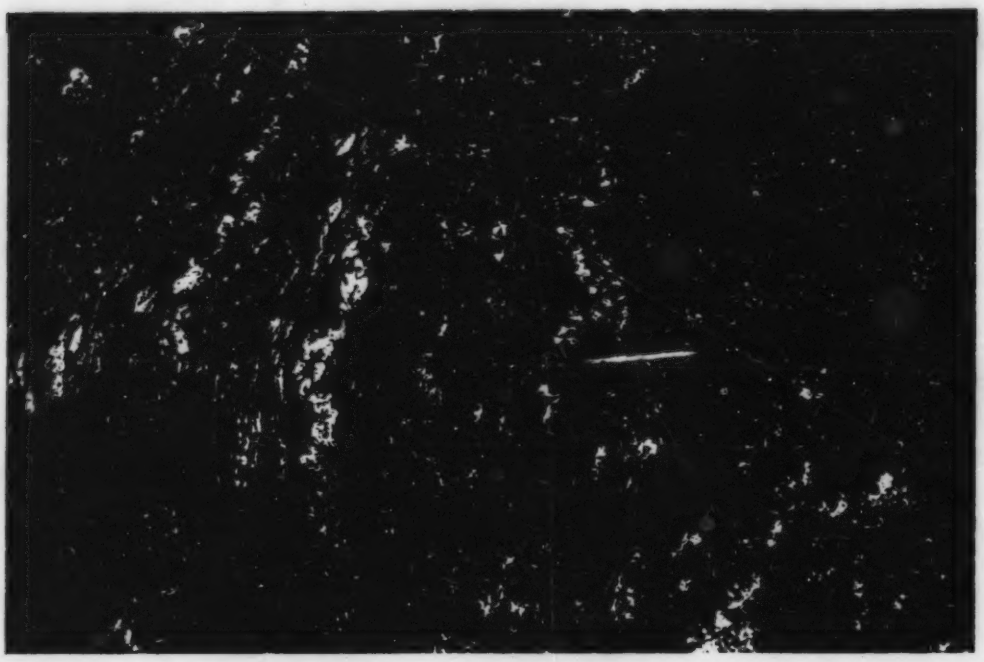


Photo 19. Typical quartzofeldspathic migmatitic gneiss of unit 23a in Awrey Township near the southwestern boundary of Street Township. Note the presence of a least 2 generations of leucosome (one is thin and subconcordant, the other is thicker and partly folded or boudinaged). Both the mesosome and the leucosome phases contain garnet. Hammer handle is 30 cm long. Station 96RME-0387. UTM 524890E 5153215N.

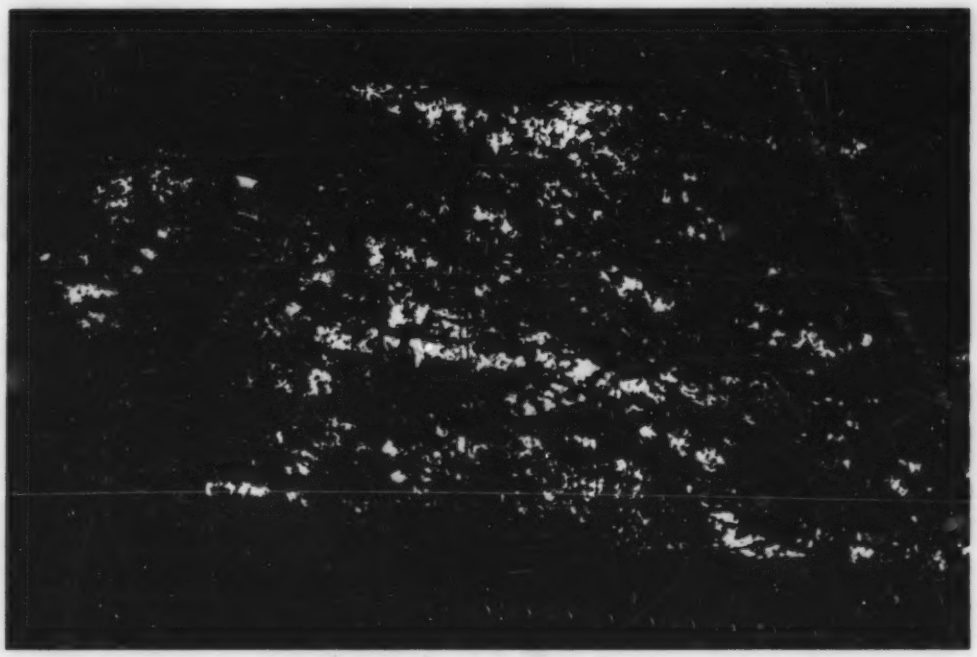


Photo 20. Typical quartzofeldspathic migmatitic gneiss of unit 23a, clearly showing the development of garnet in the mesosome and the leucosome late in the history of the rock. Hammer head is 17.5 cm across. Station 96RME-0036. UTM 528838E 5156790N.

Photo 21. Typical quartzofeldspathic migmatitic gneiss of unit 23a. The bottom two thirds of the outcrop is similar to photo 20, in that it clearly shows the development of garnet in the mesosome and the leucosome late in the history of the rock as well as the presence of a late leucosome phase immediately left of the hammer head. Upper part of the photo is a finer grained more homogeneous layer in the outcrop that is more akin to unit 22. Hammer head is 17.5 cm across. Station 96RME-0422. UTM 529790E 5156900N.

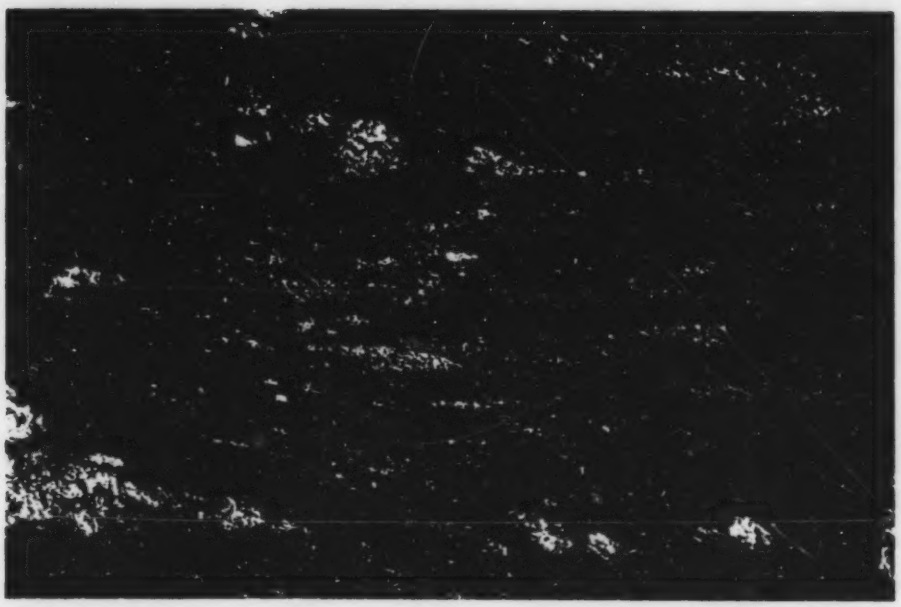


Photo 22. Quartzofeldspathic migmatitic gneiss of unit 23e, showing the presence of elongate clasts near centre of the photograph that are compositionally distinct from the boundinaged leucosome layers present at the top of the bottom. This rock may be a migmatized metaconglomerate. Rocks such as this are seen locally within migmatitic gneisses of unit 23, and indicate that much of unit 23 could have originally been a metasedimentary rock. Complete hammer handle is 30 cm long. Station 95RME-0142. UTM 529030E 5157330N.

Photo 23. Typical refolded folds present within the Grenville Province in Street Township, folding garnet amphibolite of unit 1 and biotite garnet gneiss of unit 2. Hammer handle is 30 cm long. Station 96RME-0176. UTM 529345E 5156790N.

Photo 24. Typical refolded folds present within the Grenville Province in Street Township, folding garnet amphibolite of unit 1 and biotite garnet gneiss of unit 2 near Ecosource Garnet Incorporated north zone pit. Hammer heads in the photograph point in the direction of the second generation fold axes. Hammer handle on left is 35 cm long, handle on right is 30 cm long. Station 95RME-0131. UTM 530235E 5159165N.

Photo 25. Ecosource Garnet Inc. property, photo #1. View to the east-northeast of the main stripped area of the central zone garnet exploration site of Ecosource Garnet Inc. as of July 1996. Garnet-gedrite rock shown in photo 27 and pit containing garnet and kyanite are present immediately northeast of the extreme left corner of the area shown in the photo. UTM 530250E 5159050N.

Photo 26. Ecosource Garnet Inc. property, photo #2. Large garnet grains that have weathered out of the rock shown in photo 25. This unit is located in the central zone exploration site of Ecosource Garnet Inc. Hammer handle is 30 cm long. UTM 530250E 5159050N.

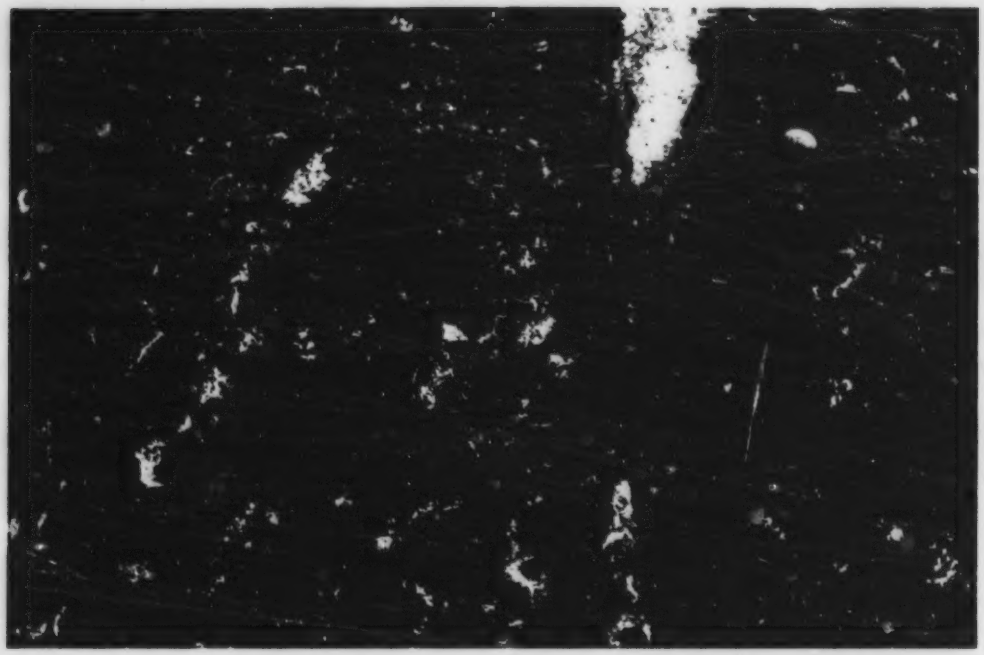


Photo 27. Ecosource Garnet Inc. property, photo #3. Garnet-gedrite gneiss of unit 1 present in the central zone exploration site of Ecosource Garnet Inc. The gneiss occurs as a pod roughly 50 m across and 100 m long within garnet-rich gneisses of unit 3. Hammer handle is 30 cm long. UTM 530250E 5159050N.

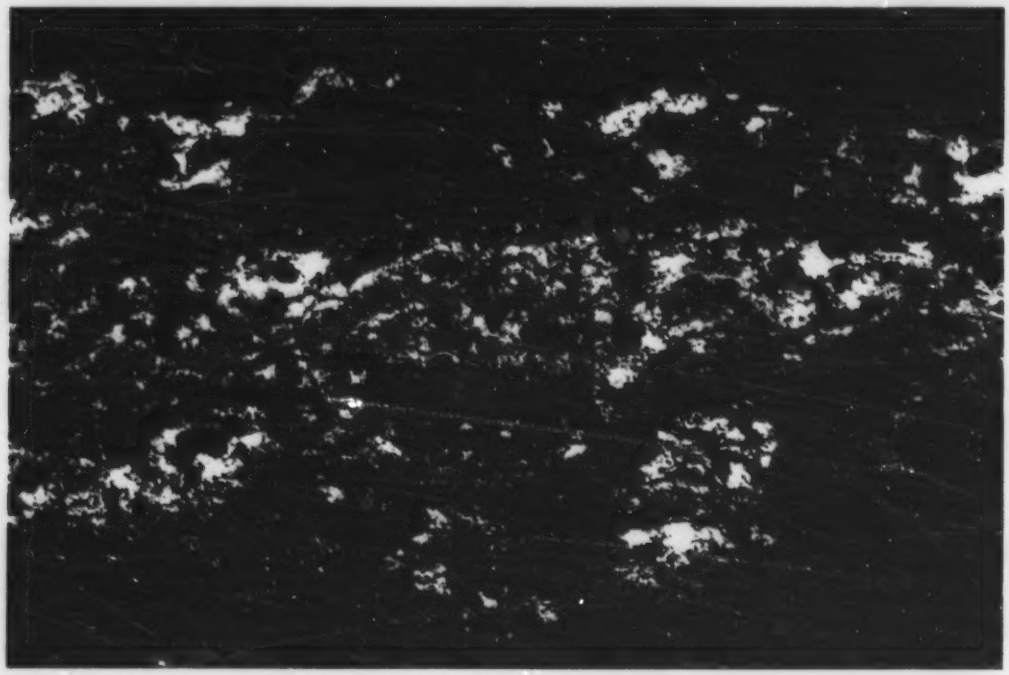


Photo 28. Ecosource Garnet Inc. property, photo #4. Garnet-rich quartzofeldspathic gneiss of unit 3 present in the south zone exploration site of Ecosource Garnet Inc. Sample 95RME-0150, Table 13 approximates the chemical composition of this rock. Complete hammer handle is 30 cm long. Station 95RME-0149. UTM 530250E 5159050N.

Appendix 1:

Listing by Map Unit of Geochemical Data Collected during this Study

Appendix 1. Listing by map unit of geochemical data collected during this study. UTM co-ordinates in NAD 27 datum, zone 17.

Sample Name	Easting	Northing	Rock Type	Map Unit	SiO_2	TiO_2	Al_2O_3	$Fe_2O_3^*$	Fe_2O_3	FeO	MnO	MgO
95RME-0132	530232	5159215	Mafic dike	1	59.48	1.42	13.12	13.55	3.20	9.31	0.16	1.67
95RME-0139	530239	5159175	Grt amphibolite	1	48.71	1.47	13.95	16.29	3.22	11.76	0.28	5.87
95RME-0140	530240	5159170	Amphibolite	1	50.75	1.08	14.01	15.22	3.35	10.68	0.26	6.51
95RME-0141	529706	5158172	Grt amphibolite	1	48.94	1.47	13.51	16.17	3.33	11.55	0.24	5.71
95RME-0144	529010	5157415	Grt amphibolite	1	66.45	1.20	13.43	9.07	1.60	6.72	0.12	0.91
95RME-0145	529025	5157405	Grt amphibolite	1	56.09	1.04	14.16	12.62	2.98	8.67	0.18	3.93
95RME-0146	529030	5157400	Grt amphibolite	1	57.83	1.41	13.31	14.08	3.31	9.69	0.18	2.41
95RME-0147	529000	5157450	Grt amphibolite	1	57.09	1.63	13.13	14.61	3.31	10.17	0.20	2.21
95RME-0148	529015	5157400	Grt amphibolite	1	67.96	0.98	13.47	8.61	1.76	6.16	0.13	0.73
96RME-0028	528675	5156195	Grt amphibolite	1	54.84	0.78	14.76	11.37	2.19	8.26	0.18	5.02
96RME-0029	528666	5156267	Grt amphibolite	1	54.84	0.83	14.72	11.67	2.41	8.33	0.19	4.62
96RME-0031	528675	5156195	Amphibolite	1	54.32	0.70	14.99	11.72	2.40	8.39	0.18	5.20
96RME-0038	528891	5156969	Amphibolite	1	52.75	0.65	14.57	10.46	1.86	7.74	0.18	7.08
96RME-0063	527000	5154020	Grt amphibolite	1	47.13	1.01	16.41	15.11	2.95	10.94	0.26	5.75
96RME-0107	529620	5158203	Grt amphibolite	1	53.80	1.59	12.95	16.49	3.31	11.86	0.22	2.85
96RME-0450	532590	5162410	Amphibolite	1	61.73	0.98	15.27	8.11	0.89	6.50	0.09	2.89
96RME-0452	532620	5162220	Amphibolite	1	56.40	1.34	12.76	13.74	3.18	9.50	0.20	3.01
96RME-0453	532630	5162210	Mafic dike	1	53.09	1.48	12.86	15.18	2.96	11.00	0.20	3.58
96RME-3020	531976	5162009	Amphibolite	1	60.29	1.02	14.85	9.49	1.71	7.00	0.13	3.01
96RME-3027	531934	5161604	Amphibolite	1	58.15	1.55	12.56	14.16	3.05	10.00	0.18	2.33
96RME-3029	532010	5161490	Amphibolite	1	58.71	1.50	12.76	13.08	2.63	9.40	0.17	2.29
96RME-3127	531934	5161604	Amphibolite	1	57.37	1.59	12.64	14.27	3.16	10.00	0.17	2.17
96RME-3150	532900	5162660	Amphibolite	1	61.24	0.93	12.04	9.95	2.39	6.80	0.14	3.18
97RME-0034	525150	5153700	Mafic grt-bi gneiss	1	49.05	1.42	14.34	18.31	3.31	13.50	0.26	6.29
96RME-0030	528680	5156144	Grt-bi gneiss	2	66.04	1.08	13.73	8.70	1.13	6.81	0.16	0.79
96RME-0033	528798	5156529	Grt-bi gneiss	2	59.95	1.03	16.51	9.57	1.60	7.17	0.07	2.91
96RME-0034	528798	5156529	Calc-silicate	2	54.30	0.77	17.55	9.06	4.04	4.52	0.12	2.69
96RME-0064	527000	5154020	Grt-bi gneiss	2	58.75	0.76	15.18	12.46	3.55	8.02	0.49	2.23
96RME-0068	527000	5154020	Grt-bi gneiss	2	61.04	1.19	12.76	13.44	2.46	9.88	0.19	2.15
96RME-0185	527560	5154760	Granetite	2	52.65	2.11	14.38	16.10	3.55	11.29	0.33	3.77
96RME-3023	531919	5161912	Paragneiss	2	56.59	0.90	16.20	6.45	1.82	5.80	0.07	3.41
96RME-3028	531983	5161597	Paragneiss	2	76.56	0.28	11.94	1.56	1.03	1.40	0.02	1.02
96RME-3032	532200	5162530	Schist	2	66.77	0.85	12.81	8.20	2.09	5.50	0.07	1.34
95RME-0133	530246	5158762	Grt-ky schist	3	45.79	2.08	30.77	13.46	2.17	10.16	0.09	1.72
95RME-0135	530208	5158707	Grt-gd gneiss	3	42.37	2.86	14.20	23.02	3.10	17.92	0.17	12.84
95RME-0136	530135	5158632	Grt schist	3	56.26	1.01	16.77	16.11	2.98	11.81	0.21	3.11
95RME-0137	530253	5159057	Grt-musc schist	3	51.73	0.96	17.53	23.86	6.80	15.35	0.30	1.31
95RME-0138	530253	5159057	Musc schist	3	79.36	0.30	10.42	3.75	0.93	2.54	0.02	0.60
95RME-0150	529636	5157943	Grt-musc schist	3	51.80	1.38	19.06	21.31	5.92	13.85	0.20	1.79
95RME-0151	529636	5157943	Grt-bi-musc schist	3	55.28	0.69	16.41	20.83	2.87	16.16	0.27	2.00
96RME-0456	527490	5154410	Amphibolite	4	55.57	0.94	13.86	13.03	2.47	9.50	0.20	3.47
96RME-0458	527200	5154370	Amphibolite	4	52.25	0.61	14.81	10.32	1.76	7.70	0.17	6.53
96RME-0459	527200	5154370	Amphibolite	4	55.37	0.52	14.61	8.85	1.52	6.60	0.14	5.72
96RME-0080	530360	5158360	Gneissic diorite	5	56.71	1.21	20.98	8.36	2.57	5.21	0.07	1.34
96RME-0164	529069	5155763	Gneissic diorite	5	54.94	0.58	15.60	10.27	2.23	7.23	0.18	5.41

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucvovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	CaO	Na_2O	K_2O	P_2O_5	H_2O^-	CO_2	S	LOI	Total	Mg No.	CIA	PIA	Cr	Ni	Co
95RME-0132	3.87	3.12	2.57	0.23	0.15	0.14	0.02	0.63	99.82	19.6	58.2	-1.7	3	15	27
95RME-0139	10.08	1.84	0.40	0.10	0.10	0.11	0.06	0.66	99.65	41.6	53.3	12.4	128	61	43
95RME-0140	8.46	3.03	0.33	0.04	0.15	0.11	0.03	0.69	100.38	45.9	54.5	12.7	134	61	42
95RME-0141	9.81	1.86	0.91	0.11	0.13	0.10	0.07	0.73	99.46	41.2	52.0	9.7	107	50	43
95RME-0144	1.33	1.82	4.90	0.24	0.15	0.11	0.01	0.31	99.78	16.6	62.8	-28.9	10	17	18
95RME-0145	8.30	2.31	1.43	0.09	0.07	0.14	0.01	0.54	100.69	38.2	54.3	8.0	21	56	39
95RME-0146	6.33	2.44	2.01	0.14	0.12	0.41	0.02	0.86	101.00	25.3	56.2	3.1	10	33	37
95RME-0147	6.05	2.69	2.04	0.18	0.15	0.09	0.03	0.58	100.41	23.0	55.1	2.8	20	28	35
95RME-0148	1.43	2.63	3.30	0.17	0.13	0.10	0.01	0.28	99.69	14.4	65.0	-9.9	6	14	16
96RME-0028	8.92	2.18	1.25	0.12	0.14	<0.10	<0.01	0.64	100.06	46.6	54.4	9.7	83	83	41
96RME-0029	8.55	2.54	1.04	0.12	0.14	<0.10	<0.01	0.52	99.63	44.0	54.8	10.5	63	74	41
96RME-0031	8.52	2.67	1.19	0.10	0.15	<0.10	<0.01	0.63	100.23	46.8	54.8	10.2	36	79	46
96RME-0038	10.07	2.09	0.82	0.08	0.15	<0.10	<0.01	0.84	99.58	57.3	52.9	11.4	147	100	39
96RME-0063	8.89	2.52	1.71	0.14	0.20	<0.10	0.01	0.76	99.69	43.0	55.6	9.9	37	95	57
96RME-0107	8.44	1.94	1.43	0.18	0.14	<0.10	<0.01	0.32	100.21	25.5	52.3	6.4	18	45	47
96RME-0450	2.63	2.83	2.96	0.15	0.26	0.18	0.08	1.17	98.81	41.4	65.0	-1.6	140	64	30
96RME-0452	6.41	3.37	2.22	0.26	0.19	0.09	0.02	0.55	100.26	30.3	51.7	1.8	36	30	40
96RME-0453	6.85	2.83	1.98	0.23	0.24	0.16	0.01	0.83	99.11	31.8	52.8	3.2	35	40	40
96RME-3020	3.60	2.66	2.60	0.17	0.24	0.10	<0.01	1.20	99.02	38.6	62.9	0.7	120	69	30
96RME-3027	4.86	2.40	2.43	0.18	0.26	0.16	0.07	0.77	99.57	24.6	56.9	-1.5	14	30	30
96RME-3029	4.24	2.86	2.72	0.19	0.27	0.13	0.01	0.72	99.24	25.8	56.8	-3.2	9	20	30
96RME-3127	5.43	2.61	2.47	0.20	0.30	0.19	0.01	0.68	99.60	23.1	55.1	-1.1	7	20	30
96RME-3150	6.33	3.11	1.00	0.10	0.13	0.10	0.03	0.76	98.78	38.8	53.8	7.1	59	50	30
97RME-0034	10.19	0.94	0.22	0.15	0.16	0.07	0.05	0.60	101.77	40.5	56.0	13.5	60	70	60
96RME-0030	0.86	2.00	4.84	0.07	0.24	<0.10	<0.01	0.65	98.92	15.2	64.1	-27.5	11	16	16
96RME-0033	2.40	2.97	2.96	0.19	0.24	<0.10	<0.01	0.85	99.41	37.6	66.5	0.9	102	63	28
96RME-0034	11.42	2.24	0.43	0.32	0.15	0.10	<0.01	0.98	99.88	37.0	55.6	16.1	48	848	90
96RME-0064	5.58	2.29	1.37	0.37	0.22	0.15	0.02	0.73	100.22	26.2	62.5	8.8	16	20	26
96RME-0068	4.13	1.64	2.01	0.23	0.23	<0.10	0.04	0.48	99.26	24.1	62.1	0.6	24	22	22
96RME-0185	8.93	0.18	0.71	0.63	0.25	0.12	0.07	0.64	100.43	31.7	59.7	11.2	71	5	6
96RME-3023	1.84	1.45	4.31	0.12	0.36	2.40	0.09	5.34	96.68	51.2	75.7	-17.5	150	85	30
96RME-3028	0.41	1.18	3.36	0.01	0.18	0.12	<0.01	1.64	97.98	56.5	71.2	-21.5	9	20	6
96RME-3032	0.76	3.68	3.25	0.12	0.40	0.33	0.01	1.27	99.12	24.4	63.5	-11.0	61	20	9
95RME-0133	2.22	2.48	0.51	0.04	0.12	0.09	0.12	0.01	99.17	20.2	85.7	29.3	349	61	30
95RME-0135	1.43	0.83	0.23	0.22	0.11	0.09	0.04	0.40	98.57	52.5	85.5	12.8	67	110	61
95RME-0136	2.28	2.58	1.37	0.18	0.12	0.09	0.08	0.01	99.89	27.7	73.2	10.0	145	66	44
95RME-0137	2.18	0.03	1.82	0.04	0.14	0.15	1.09	0.02	99.78	9.8	81.9	7.3	186	97	57
95RME-0138	0.41	0.13	2.70	0.04	0.14	0.68	0.13	2.10	99.83	24.0	80.3	-25.2	32	21	10
95RME-0150	0.98	0.13	2.26	0.10	0.16	0.09	0.16	0.22	99.23	14.3	85.3	6.4	99	67	49
95RME-0151	2.04	1.30	1.18	0.04	0.12	0.13	0.45	0.01	100.05	16.0	78.9	10.0	183	81	48
96RME-0456	7.74	2.53	1.52	0.08	0.12	0.08	<0.01	0.50	99.44	34.5	54.2	7.1	10	40	40
96RME-0458	9.71	2.52	1.13	0.04	0.15	0.08	<0.01	1.31	99.40	55.6	52.7	10.4	180	110	40
96RME-0459	9.18	2.68	1.05	0.02	0.15	0.08	<0.01	0.51	98.65	56.1	53.2	10.5	160	95	30
96RME-0080	4.02	5.66	1.95	0.09	0.26	0.13	<0.01	0.61	101.00	24.1	64.6	14.2	334	120	45
96RME-0164	9.51	2.25	0.61	0.08	0.16	<0.10	<0.01	0.64	100.06	51.1	55.8	13.3	20	69	37

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	Sc	V	Cu	Pb	Zn	W	Mo	As	Rb	Cs	Be	Ba	Sr	Ta	Nb	Hf	Zr		Th
95RME-0132	22	82	34	22	126	<35	<8	<6	128	NA	<3	1052	194	NA	16.0	NA	262	57	20.0
95RME-0139	34	336	176	10	125	<35	<8	<6	7	NA	3	73	209	NA	7.0	NA	105	32	<10
95RME-0140	31	295	89	8	110	<35	<8	<6	10	NA	3	225	126	NA	4.0	NA	85	28	<10
95RME-0141	36	331	167	6	118	<35	<8	<6	19	NA	3	238	119	NA	7.0	NA	122	38	<10
95RME-0144	13	86	5	25	113	<35	<8	<6	140	NA	<3	1070	144	NA	16.0	NA	325	38	<10
95RME-0145	24	206	94	16	111	<35	<8	<6	25	NA	3	327	169	NA	11.0	NA	179	39	<10
95RME-0146	25	293	150	21	126	<35	<8	<6	78	NA	3	761	150	NA	13.0	NA	228	47	11.0
95RME-0147	26	224	130	19	126	<35	<8	<6	64	NA	3	659	155	NA	13.0	NA	218	52	20.0
95RME-0148	11	76	10	17	115	<35	<8	<6	106	NA	<3	886	266	NA	13.0	NA	285	35	10.0
96RME-0028	25	170	100	13	110	<35	<8	<6	15	NA	<3	492	143	NA	10.0	NA	161	37	<10
96RME-0029	25	180	81	14	86	<35	<8	<6	15	NA	<3	335	197	NA	11.0	NA	172	38	10.0
96RME-0031	27	190	89	12	100	<35	<8	<6	14	NA	<3	248	172	NA	9.0	NA	145	33	<10
96RME-0038	32	200	47	<7	76	<35	8	<6	13	NA	<3	242	188	NA	6.0	NA	106	26	<10
96RME-0063	34	240	72	13	150	<35	<8	<6	52	NA	<3	541	153	NA	11.0	NA	200	53	15.0
96RME-0107	30	280	80	18	140	<35	<8	<6	17	NA	3	447	182	NA	11.0	NA	192	46	12.0
96RME-0450	14	140	88	16	110	<35	<8	<6	96	7.30	<3	1100	420	0.78	11.0	3.00	190	24	8.8
96RME-0452	27	250	140	10	130	<35	<8	<6	80	1.60	<3	680	200	0.56	10.0	1.30	220	44	7.6
96RME-0453	30	310	80	12	140	<35	<8	<6	60	0.65	3	630	180	0.49	8.8	1.00	190	40	5.8
96RME-3020	17	150	71	12	120	<35	<8	<6	88	1.30	<3	940	370	0.73	13.0	0.94	190	28	9.4
96RME-3027	25	180	100	14	130	<35	<8	<6	88	2.10	<3	970	150	1.20	16.0	3.80	230	51	18.0
96RME-3029	24	150	20	21	130	<35	<8	<6	110	4.50	<3	820	150	1.20	16.0	3.40	220	50	17.0
96RME-3127	26	180	57	18	130	<35	<8	<6	120	2.60	3	590	120	1.20	17.0	3.00	220	53	15.0
96RME-3150	19	190	310	37	91	<35	<8	<6	15	0.18	<3	240	320	0.46	7.2	1.20	120	23	4.7
97RME-0034	49	411	236	9	126	<35	<8	<6	2	0.03	3	72	55	NA	7.0	NA	113	38	3.2
96RME-0030	13	80	4	20	116	<35	8	<6	107	NA	<3	1371	333	NA	14.0	NA	338	50	14.0
96RME-0033	17	138	4	15	85	<35	12	<6	93	NA	<3	612	351	NA	12.0	NA	207	30	10.0
96RME-0034	16	108	147	15	83	<35	11	<6	6	NA	<3	46	684	NA	9.0	NA	198	37	<10
96RME-0064	18	49	100	17	66	<35	<8	<6	70	NA	3	785	182	NA	8.0	NA	348	90	48.0
96RME-0068	20	37	72	13	171	<35	8	<6	97	NA	<3	1148	144	NA	20.0	NA	370	67	22.0
96RME-0185	3	21	4	14	16	<35	<8	<6	20	NA	<3	136	125	NA	13.0	NA	225	57	<10
96RME-3023	17	140	81	16	130	<35	<8	27	170	6.10	<3	750	110	0.37	3.4	4.60	160	29	11.0
96RME-3028	5	40	7	12	35	<35	<8	<6	140	6.10	<3	790	86	0.54	6.1	2.00	90	10	6.2
96RME-3032	13	30	9	14	110	<35	<8	<6	150	25.0	<3	1200	200	1.60	27.0	13.0	460	35	14.0
95RME-0133	34	137	58	23	40	<35	<8	<6	24	NA	<3	240	151	NA	34.0	NA	379	75	<10
95RME-0135	15	475	56	11	113	<35	<8	<6	17	NA	3	121	7	NA	16.0	NA	224	49	11.0
95RME-0136	27	196	114	12	110	<35	<8	<6	54	NA	<3	809	56	NA	12.0	NA	216	49	<10
95RME-0137	28	188	228	17	96	<35	<8	<6	64	NA	<3	894	12	NA	9.0	NA	183	53	<10
95RME-0138	5	37	37	<7	23	<35	<8	12	85	NA	<3	661	14	NA	4.0	NA	99	12	<10
95RME-0150	33	305	79	13	67	<35	<8	<6	69	NA	<3	1595	12	NA	21.0	NA	467	112	92.0
95RME-0151	41	143	248	12	70	<35	<8	<6	52	NA	<3	553	59	NA	7.0	NA	473	86	10.0
96RME-0456	27	200	130	15	110	<35	<8	<6	33	0.15	<3	410	160	0.75	11.0	2.30	200	41	12.0
96RME-0458	27	160	51	14	92	<35	<8	<6	15	0.06	<3	220	180	0.43	7.3	1.30	120	28	7.1
96RME-0459	23	140	40	14	78	<35	<8	<6	14	0.06	<3	220	210	0.38	6.5	1.20	110	24	6.2
96RME-0080	33	240	<5	25	77	<35	18	18	69	NA	4	975	318	NA	13.0	NA	228	45	19.0
96RME-0164	31	210	56	9	81	<35	<8	<6	12	NA	<3	233	200	NA	5.0	NA	91	22	<10

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucvovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	U	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
95RME-0132	NA	48.11	94.72	11.89	45.01	9.87	2.04	10.10	1.64	10.06	2.02	5.96	0.86	5.63	0.86
95RME-0139	NA	11.03	24.56	3.36	14.39	3.81	1.15	4.55	0.78	5.05	1.05	3.09	0.45	3.00	0.46
95RME-0140	NA	5.42	14.20	2.25	10.33	2.99	1.04	3.84	0.64	4.33	0.90	2.60	0.38	2.47	0.38
95RME-0141	NA	15.50	33.59	4.50	18.98	4.78	1.37	5.42	0.92	6.07	1.27	3.67	0.53	3.52	0.55
95RME-0144	NA	60.28	125.02	15.93	60.30	11.47	2.43	9.43	1.35	7.13	1.38	3.86	0.53	3.45	0.51
95RME-0145	NA	30.80	61.16	7.61	28.98	6.14	1.48	6.34	1.03	6.35	1.29	3.75	0.55	3.51	0.55
95RME-0146	NA	37.37	74.23	9.17	34.68	7.33	1.68	7.43	1.22	7.43	1.52	4.44	0.65	4.14	0.63
95RME-0147	NA	37.46	77.97	9.75	37.62	8.54	2.04	8.76	1.46	9.00	1.82	5.26	0.78	4.96	0.75
95RME-0148	NA	53.23	109.64	13.85	51.83	9.75	2.30	8.09	1.19	6.55	1.27	3.53	0.51	3.29	0.49
96RME-0028	NA	27.44	55.33	6.81	26.11	5.60	1.28	5.66	0.95	5.69	1.22	3.55	0.53	3.38	0.51
96RME-0029	NA	29.01	59.50	7.39	28.11	6.00	1.35	6.06	1.01	6.12	1.31	3.84	0.57	3.63	0.56
96RME-0031	NA	28.36	55.26	6.99	26.39	5.49	1.26	5.43	0.88	5.37	1.15	3.30	0.49	3.13	0.46
96RME-0038	NA	16.96	35.62	4.39	17.22	3.72	0.96	3.82	0.64	3.88	0.83	2.39	0.35	2.30	0.36
96RME-0063	NA	47.45	84.09	11.16	41.05	8.19	1.68	8.00	1.37	8.49	1.93	5.93	0.91	5.91	0.93
96RME-0107	NA	22.26	51.44	6.30	25.16	6.26	1.64	6.86	1.19	7.35	1.62	4.79	0.71	4.57	0.71
96RME-0450	2.2	43.00	89.00	11.00	40.00	7.20	1.90	6.20	0.85	4.30	0.80	2.30	0.31	2.10	0.33
96RME-0452	1.1	39.00	83.00	10.00	38.00	8.00	1.90	8.10	1.20	7.20	1.50	4.40	0.61	4.10	0.62
96RME-0453	0.9	32.00	69.00	8.60	34.00	7.20	1.80	7.40	1.20	6.60	1.40	4.10	0.57	3.80	0.58
96RME-3020	1.9	45.00	94.00	11.00	42.00	8.00	2.00	7.20	1.00	5.60	1.10	3.20	0.45	3.00	0.46
96RME-3027	5.2	42.00	85.00	10.00	38.00	8.60	2.00	9.10	1.50	9.00	1.90	5.60	0.80	5.30	0.80
96RME-3029	4.4	43.00	85.00	10.00	38.00	8.20	1.80	8.60	1.40	8.60	1.80	5.40	0.79	5.10	0.75
96RME-3127	4.3	27.00	61.00	7.00	28.00	7.00	1.70	7.90	1.40	8.40	1.80	5.40	0.80	5.10	0.77
96RME-3150	1.4	22.00	48.00	6.00	23.00	4.80	1.50	4.60	0.70	4.00	0.81	2.40	0.32	2.20	0.33
97RME-0034	1.1	13.66	29.83	3.92	17.69	4.66	1.36	5.01	0.86	6.08	1.32	4.06	0.58	4.04	0.65
96RME-0030	NA	65.12	326.31	17.25	64.12	11.72	2.57	9.21	1.38	7.83	1.69	4.74	0.68	4.32	0.64
96RME-0033	NA	48.03	100.56	12.60	47.00	8.77	2.00	7.01	1.05	5.53	1.09	3.00	0.43	2.78	0.41
96RME-0034	NA	41.46	85.29	10.25	39.11	7.52	2.42	6.91	1.05	5.85	1.19	3.30	0.46	2.89	0.43
96RME-0064	NA	47.62	161.94	10.68	36.67	6.76	1.46	8.06	1.62	12.55	3.30	11.24	1.85	12.94	2.15
96RME-0068	NA	44.64	99.12	11.74	44.72	9.87	1.81	10.36	1.80	11.41	2.44	7.08	1.05	6.69	1.03
96RME-0185	NA	35.64	79.97	10.46	43.33	10.17	3.05	10.37	1.66	9.73	2.00	5.52	0.78	4.97	0.76
96RME-3023	2.6	43.00	88.00	10.00	38.00	7.10	1.60	5.80	0.69	2.70	0.33	0.94	0.09	0.67	0.11
96RME-3028	2.1	27.00	55.00	6.20	21.00	3.20	0.87	2.50	0.34	1.50	0.21	0.70	0.07	0.53	0.09
96RME-3032	3.4	23.00	66.00	5.90	22.00	4.60	1.20	4.60	0.80	5.30	1.20	4.00	0.65	4.80	0.81
95RME-0133	NA	22.70	45.11	5.48	20.23	3.91	1.40	5.48	1.20	9.11	2.05	6.31	0.94	6.25	0.99
95RME-0135	NA	35.28	72.29	9.02	34.88	7.09	1.62	7.16	1.17	7.28	1.54	4.65	0.68	4.46	0.70
95RME-0136	NA	30.12	62.65	7.97	30.76	6.85	1.63	7.40	1.28	8.09	1.68	4.95	0.73	4.76	0.75
95RME-0137	NA	27.76	56.78	7.11	27.90	6.63	1.60	8.47	1.47	9.39	1.84	5.18	0.73	4.68	0.69
95RME-0138	NA	15.47	31.60	3.72	13.32	2.39	0.60	1.75	0.22	0.90	0.16	0.43	0.07	0.47	0.08
95RME-0150	NA	289.95	500.02	77.22	291.88	49.65	5.01	33.02	3.92	17.20	3.50	10.27	1.52	10.30	1.56
95RME-0151	NA	18.59	37.64	4.61	17.25	3.80	1.12	7.40	1.75	13.72	3.02	9.11	1.37	8.82	1.34
96RME-0456	1.9	35.00	68.00	8.20	31.00	6.50	1.40	6.80	1.10	6.60	1.40	4.10	0.58	3.80	0.59
96RME-0458	1.2	19.00	39.00	4.70	18.00	4.00	1.00	4.30	0.70	4.30	0.89	2.60	0.36	2.50	0.38
96RME-0459	1.0	16.00	34.00	4.00	15.00	3.30	0.90	3.70	0.61	3.60	0.74	2.20	0.30	2.10	0.32
96RME-0080	NA	51.94	105.18	12.28	44.91	8.68	1.79	7.94	1.25	7.45	1.58	4.69	0.70	4.45	0.69
96RME-0164	NA	12.68	27.35	3.57	13.03	2.97	0.91	3.15	0.52	3.30	0.71	2.14	0.31	2.05	0.31

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucvovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	Easting	Northing	Rock Type	Map Unit	SiO_2	TiO_2	Al_2O_3	Fe_2O_3*	Fe_2O_3	FeO	MnO	MgO
96RME-0041	528938	5157144	Opx hornblendite	6	46.20	0.27	5.29	12.66	2.29	9.33	0.14	27.04
96RME-0267	524960	5153570	Opx hornblendite	6	47.25	0.31	5.40	12.38	5.16	6.50	0.13	26.83
96RME-0341	528270	5153690	Opx hornblendite	6	50.49	0.32	6.01	10.99	3.54	6.70	0.19	24.17
97RME-0033	325400	5151800	Opx hornblendite	6	48.28	0.42	8.27	11.69	3.24	7.60	0.21	22.48
97RME-0035	525150	5153700	Ath schist	6	53.05	0.36	4.71	11.86	1.38	9.43	0.23	21.43
97RME-0036	524100	5150800	Opx hornblendite	6	46.89	1.06	6.06	13.59	4.09	8.55	0.24	17.34
97RME-0037	524100	5150800	Opx hornblendite	6	46.48	1.33	6.88	14.05	3.47	9.52	0.19	18.85
98RME-0049	530550	5155060	Opx hornblendite	6	47.81	1.15	6.76	14.83	4.71	9.11	0.22	18.36
98RME-0055	530100	5155360	Hornblendite	6	46.89	1.06	6.06	13.59	3.39	9.18	0.24	17.34
H98-103	525150	5153700	Blackwall	6	46.79	0.42	8.03	13.40			0.16	18.75
H98-110	525150	5153700	Cgr hornblendite	6	46.79	0.52	11.46	11.38			0.15	15.45
H98-120	525150	5153700	Sheared opx hbl	6	47.11	0.37	5.63	11.42			0.21	23.92
H98-200	525150	5153700	Ath dike	6	52.35	0.25	4.08	13.97			0.22	24.59
H98-202	525150	5153700	Ath schist	6	53.11	0.38	5.20	11.12			0.20	21.69
H98-300	525150	5153700	Grt amphibolite	1	50.00	0.73	14.54	16.34			0.41	6.71
H98-317	525150	5153700	Black amphibolite	7	48.55	0.16	15.81	6.62			0.12	12.23
H98-401	525150	5153700	Radial amphibolite	6	38.23	2.60	10.12	12.83			0.20	13.24
H98-406	525150	5153700	Opx hornblendite	6	48.00	0.31	5.88	12.31			0.14	25.01
H98-408	525150	5153700	Opx hornblendite	6	49.97	0.35	6.16	12.86			0.21	22.95
H98-409	525150	5153700	Ol hornblendite	6	45.96	0.40	7.95	9.81			0.13	20.82
96RME-0200	529378	5154441	Black amphibolite	7	50.94	0.38	13.32	8.06	0.45	6.85	0.16	10.91
96RME-0457	527405	5154410	Black amphibolite	7	53.24	0.50	12.16	9.85	1.40	7.60	0.17	9.91
96RME-0460	527940	5153600	Black amphibolite	7	50.95	0.37	15.91	8.03	1.25	6.10	0.14	9.10
98RME-0022	529782	5154944	Anor gabbro	7	49.91	1.36	16.71	14.91	3.94	9.87	0.18	3.43
98RME-0024	530387	5155115	Anor gabbro	7	49.48	0.28	16.86	9.19	3.23	5.36	0.15	8.46
98RME-0027	531137	5155400	Black amphibolite	7	52.26	0.49	14.77	10.25	1.81	7.59	0.18	8.93
98RME-0038	530178	5154729	Black amphibolite	7	51.11	0.41	14.09	8.75	1.46	6.56	0.17	9.83
98RME-0047	530433	5154949	Black amphibolite	7	51.31	0.46	15.59	10.01	2.14	7.08	0.17	7.28
98RME-0048	530433	5154949	Grt amphibolite	7	52.12	0.56	16.83	11.26	2.30	8.06	0.14	6.27
98RME-0051	534000	5155075	Anor gabbro	7	52.11	0.61	17.11	9.97	1.86	7.30	0.16	6.03
98RME-0053	530240	5155175	Black amphibolite	7	51.11	0.45	15.41	10.09	1.90	7.37	0.16	8.44
98RME-0074	529975	5155060	Anor gabbro	7	49.64	0.67	19.48	10.90	2.35	7.69	0.14	4.40
96RME-0213	530640	5155255	Anor gabbro	8	48.88	0.49	19.59	10.24	2.91	6.60	0.16	5.13
98RME-0023	530055	5155115	Gabbro anor	8	48.01	0.83	19.78	11.24	2.04	8.28	0.14	4.91
98RME-0025	530469	5155301	Gabbro anor	8	48.20	0.27	23.65	6.72	1.85	4.38	0.11	4.52
98RME-0030	530760	5155098	Leuconorite	8	51.69	0.44	14.36	9.75	0.96	7.91	0.18	9.53
98RME-0031	530549	5155130	Hb-plag pegmatite	8	55.35	0.16	23.09	3.01	0.84	1.95	0.05	2.31
98RME-0050	530475	5154989	Gabbro anor	8	53.58	0.77	18.65	9.16	2.51	5.98	0.12	3.29
98RME-0052	530268	5155150	Leuconorite	8	51.70	0.46	14.96	10.22	0.94	8.35	0.18	8.75
98RME-0062	530650	5155060	Leuconorite	8	51.64	0.43	15.88	8.49	0.93	6.80	0.15	8.90
96RME-0049	528569	5153821	Monzogranite	9	70.61	0.33	12.31	5.37	1.95	3.08	0.10	0.59
96RME-0451	532460	5162155	Monzogranite	9	71.07	0.34	12.28	4.67	1.45	2.90	0.08	0.30
96RME-0454	532620	5162255	Monzogranite	9	69.25	0.34	12.40	5.48	2.37	2.80	0.11	0.27
96RME-0461	528790	5154110	Monzogranite	9	68.37	0.62	12.54	6.51	3.06	3.10	0.12	0.84
96RME-0602	528806	5154033	Monzogranite	9	69.88	0.53	12.15	6.10	2.88	2.90	0.12	0.51
96RME-0606	532050	5162180	Monzogranite	9	67.59	0.70	12.55	6.85	2.18	4.20	0.10	0.60
96RME-3008	532021	5162242	Monzogranite	9	69.56	0.60	11.83	6.21	2.88	3.00	0.08	0.34
96RME-3015	531800	5162012	Breccia (granitic)	9	61.02	1.05	15.04	9.01	1.23	7.00	0.10	3.15
96RME-3022	531929	5161949	Granite gneiss	9	66.98	0.82	12.13	8.31	2.09	5.60	0.11	0.55
96RME-3026	531849	5161710	Granite gneiss	9	71.00	0.34	12.09	5.39	2.61	2.50	0.11	0.28
96RME-3036	532236	5162242	Fault gouge	24	72.02	0.33	11.85	4.10	1.54	2.30	0.05	0.78

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	CaO	Na_2O	K_2O	P_2O_5	H_2O^-	CO_2	S	LOI	Total	Mg No.	CIA	PIA	Cr	Ni	Co
96RME-0041	3.89	0.02	0.05	0.03	0.23	0.11	0.01	2.74	98.32	80.9	57.9	4.7	>3000	870	91
96RME-0267	4.13	0.28	0.05	0.04	0.22	<0.10	<0.01	2.24	99.05	81.1	54.8	4.9	>3000	850	16
96RME-0341	5.55	0.62	0.08	<0.01	0.12	0.10	<0.01	0.27	98.69	81.3	49.4	5.3	2900	880	73
97RME-0033	7.81	0.44	0.13	<0.01	0.10	0.19	<0.01	0.51	100.24	79.2	50.2	7.5	>3000	750	62
97RME-0035	6.13	0.60	0.05	0.02	0.21	0.25	<0.01	1.45	99.89	78.2	41.9	4.3	2170	406	72
97RME-0036	11.09	0.68	0.13	0.13	0.18	1.46	0.02	2.40	99.61	71.6	36.7	5.3	1384	1106	84
97RME-0037	9.16	0.43	0.07	0.16	0.23	1.32	0.07	2.91	100.51	72.7	45.2	6.4	839	946	88
98RME-0049	9.82	0.48	0.06	0.13	0.23	0.17	<0.01	0.54	100.16	71.0	39.9	6.4	1334	1008	91
98RME-0055	11.09	0.68	0.13	0.13	0.28	0.84	<0.01	2.40	99.61	71.6	35.4	5.3	1262	1051	76
H98-103	6.09	0.23	2.99	0.06	NA	NA	NA	3.18	100.10	73.5	46.3	-18.3	2720	626	103
H98-110	10.12	1.36	0.19	0.03	NA	NA	NA	2.48	99.93	72.9	49.5	10.6	1377	254	87
H98-120	4.69	0.27	0.03	0.06	NA	NA	NA	6.21	99.92	80.6	53.0	5.3	4029	884	118
H98-200	0.54	0.01	0.09	0.00	NA	NA	NA	4.13	100.23	77.7	86.4	2.1	3801	601	121
H98-202	4.95	0.80	0.06	0.05	NA	NA	NA	2.66	100.22	79.4	47.2	4.6	2492	381	94
H98-300	7.48	1.52	0.40	0.31	NA	NA	NA	1.69	100.13	44.9	60.7	12.8	59	1	109
H98-317	10.73	1.65	0.23	0.02	NA	NA	NA	3.74	99.86	78.5	55.6	15.0	845	158	57
H98-401	13.92	3.12	1.40	1.05	NA	NA	NA	0.00	96.71	67.1	35.4	4.7	345	262	58
H98-406	3.52	0.41	0.08	0.04	NA	NA	NA	4.19	99.89	80.1	59.5	5.1	4723	1019	106
H98-408	5.60	0.35	0.13	0.05	NA	NA	NA	1.61	100.24	77.9	50.3	5.1	3330	862	98
H98-409	9.10	0.40	0.16	0.03	NA	NA	NA	5.06	99.82	80.8	45.1	7.0	3027	752	90
96RME-0200	13.87	1.10	0.45	0.04	0.12	<0.10	0.02	0.69	99.92	72.8	46.3	11.7	1134	170	36
96RME-0457	9.95	1.61	0.85	0.01	0.14	0.10	<0.01	0.65	98.90	66.6	49.7	8.4	830	190	50
96RME-0460	11.23	1.60	0.75	-0.01	0.17	0.09	<0.01	0.69	98.76	69.2	54.1	13.2	760	140	40
98RME-0022	8.59	3.66	1.26	0.17	0.21	0.12	<0.01	0.50	100.68	31.3	55.5	12.1	8	40	46
98RME-0024	13.15	1.97	0.24	0.03	0.12	0.11	<0.01	0.58	100.39	64.6	52.5	16.1	578	162	49
98RME-0027	12.07	1.62	0.31	0.04	0.13	0.10	0.05	0.63	101.55	63.3	51.5	13.7	115	139	47
98RME-0038	12.73	1.41	0.40	0.03	0.11	0.45	0.04	0.93	99.86	69.0	50.0	12.6	473	187	43
98RME-0047	11.20	1.99	0.45	0.04	0.42	0.64	0.05	1.62	100.12	59.0	54.5	14.0	75	109	45
98RME-0048	10.93	2.03	0.52	0.05	0.19	0.14	<0.01	0.70	101.41	52.4	55.8	15.0	43	88	44
98RME-0051	11.00	1.87	0.55	0.06	0.26	0.14	0.04	0.85	100.32	54.5	56.3	15.2	31	83	41
98RME-0053	11.60	1.98	0.36	0.04	0.23	0.18	0.01	1.04	100.68	62.4	52.8	14.1	99	132	49
98RME-0074	9.88	3.19	0.87	0.05	0.23	0.24	<0.01	0.96	100.18	44.4	53.7	16.7	16	60	45
96RME-0213	10.84	2.92	0.68	0.08	0.13	<0.10	<0.01	0.61	99.62	49.8	57.6	17.5	48	73	40
98RME-0023	10.95	2.94	0.80	0.04	0.17	0.09	<0.01	0.56	100.20	46.4	57.5	17.3	30	78	44
98RME-0025	12.49	3.01	0.32	0.03	0.13	0.11	<0.01	0.57	99.89	57.1	60.1	22.8	111	64	26
98RME-0030	12.58	1.41	0.27	0.03	0.18	0.11	0.03	0.18	100.42	65.9	50.4	13.4	167	165	50
98RME-0031	8.02	5.00	1.14	0.01	0.32	0.20	<0.01	1.06	99.20	60.3	62.3	19.8	25	36	11
98RME-0050	7.14	4.27	1.73	0.09	0.35	0.32	<0.01	1.08	99.88	41.6	59.3	12.5	11	36	33
98RME-0052	12.17	1.56	0.29	0.04	0.25	0.14	0.04	0.26	100.59	62.9	51.9	13.9	102	141	52
98RME-0062	12.88	1.50	0.25	0.04	0.27	0.14	0.03	0.39	100.55	67.5	52.3	15.0	563	171	43
96RME-0049	1.31	3.57	3.91	0.08	0.19	0.57	<0.01	1.07	99.25	17.9	60.0	-18.5	22	10	-5
96RME-0451	1.58	3.16	4.74	0.00	0.21	0.23	0.01	0.56	98.78	11.3	57.0	-27.1	6	<5	<5
96RME-0454	1.62	3.56	4.94	0.01	0.19	0.16	<0.01	0.37	98.35	8.9	55.5	-27.2	6	<5	<5
96RME-0461	2.67	3.77	3.77	0.18	0.19	0.11	<0.01	0.31	99.70	20.4	55.4	-12.4	3	6	10
96RME-0602	2.11	3.43	4.13	0.08	0.17	0.60	<0.01	0.35	99.39	14.2	57.3	-19.7	3	6	<5
96RME-0606	3.32	3.25	3.60	0.11	0.18	0.38	<0.01	0.86	99.53	14.8	56.2	-11.2	4	7	6
96RME-3008	2.01	3.20	4.13	0.04	0.19	0.12	<0.01	0.37	98.37	9.8	56.2	-20.5	3	6	6
96RME-3015	2.39	2.66	2.89	0.15	0.26	0.10	0.05	1.02	98.48	40.9	65.7	-1.9	170	73	30
96RME-3022	2.81	2.91	3.53	0.14	0.16	0.21	0.02	0.53	98.82	11.6	57.3	-12.9	4	7	10
96RME-3026	1.53	3.63	4.46	0.02	0.17	0.09	<0.01	0.35	99.20	9.3	55.9	-23.0	7	7	<5
96RME-3036	0.61	1.92	5.94	0.00	0.35	0.18	0.01	1.28	98.88	27.4	58.8	-60.1	10	7	<5

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	Sc	V	Cu	Pb	Zn	W	Mo	As	Rb	Cs	Be	Ba	Sr	Ta	Nb	Hf	Zr	Y	Th
96RME-0041	17	110	160	<7	88	<35	13	<6	4	NA	<3	24	14	NA	3.0	NA	37	14	<10
96RME-0267	17	150	16	<7	81	<35	12	<6	3	NA	<3	20	20	NA	3.0	NA	42	10	<3
96RME-0341	16	110	<5	<7	52	<35	<8	<6	1	0.03	<3	33	4	0.24	2.6	0.80	41	12	1.7
97RME-0033	20	140	9	<7	57	<35	13	<6	1	<0.10	<3	10	20	0.31	3.6	NA	59	11	2.1
97RME-0035	29	158	6	<7	106	<35	<8	<6	1	0.03	<3	36	23	NA	0.8	NA	51	11	1.4
97RME-0036	18	171	215	8	172	<35	<8	<6	1	0.10	<3	17	50	NA	12.8	NA	106	16	3.6
97RME-0037	18	186	159	<7	142	<35	<8	<6	1	0.10	<3	-8	14	NA	15.9	NA	123	20	3.5
98RME-0049	19	183	27	7	143	<35	<8	<6	1	0.05	<3	26	13	NA	14.0	NA	116	19	3.8
98RME-0055	18	176	5	<7	127	<35	<8	<6	6	0.10	<3	46	34	NA	9.3	NA	87	14	1.0
H98-103	24	147	2	NA	77	NA	NA	NA	154	NA	NA	885	17	NA	1.1	NA	57	20	NA
H98-110	42	233	56	NA	57	NA	NA	NA	2	NA	NA	19	51	NA	0.8	NA	74	25	NA
H98-120	20	127	16	NA	48	NA	NA	NA	0	NA	NA	2	12	NA	0.5	NA	44	5	NA
H98-200	5	104	1	NA	78	NA	NA	NA	2	NA	NA	35	9	NA	3.6	NA	23	6	NA
H98-202	30	147	1	NA	68	NA	NA	NA	1	NA	NA	35	24	NA	5.2	NA	63	14	NA
H98-300	44	311	100	NA	1	NA	NA	NA	1	NA	NA	190	80	NA	0.3	NA	100	46	NA
H98-317	27	89	1	NA	53	NA	NA	NA	1	NA	NA	6	179	NA	1.4	NA	22	6	NA
H98-401	21	236	79	NA	113	NA	NA	NA	43	NA	NA	999	1374	NA	105	NA	267	32	NA
H98-406	22	127	79	NA	53	NA	NA	NA	2	NA	NA	1	16	NA	1.5	NA	43	8	NA
H98-408	22	131	40	NA	55	NA	NA	NA	<1	NA	NA	1	11	NA	0.9	NA	56	13	NA
H98-409	26	152	1	NA	65	NA	NA	NA	<1	NA	NA	1	21	NA	1.0	NA	51	19	NA
96RME-0200	40	200	68	<7	56	<35	<8	<6	8	NA	<3	94	98	NA	3.0	NA	32	13	<10
96RME-0457	28	150	54	9	79	<35	<8	<6	17	0.09	<3	180	140	0.38	5.8	1.20	96	22	5.6
96RME-0460	24	140	52	7	65	<35	<8	<6	24	0.33	<3	190	170	0.21	3.0	1.40	62	16	2.4
98RME-0022	33	351	185	9	149	<35	<8	<6	23	0.16	3	333	248	NA	6.0	NA	123	30	4.0
98RME-0024	40	164	6	8	72	<35	<8	<6	3	0.03	<3	73	234	NA	0.8	NA	29	9	0.6
98RME-0027	43	241	172	11	90	<35	<8	<6	11	0.37	<3	100	121	NA	1.6	NA	40	13	1.1
98RME-0038	41	220	157	8	80	<35	<8	<6	11	0.25	<3	112	113	NA	1.4	NA	35	11	1.0
98RME-0047	37	217	114	<7	91	<35	<8	<6	14	0.39	<3	125	157	NA	1.7	NA	42	13	1.2
98RME-0048	35	236	36	8	110	<35	<8	<6	15	0.14	<3	150	167	NA	1.8	NA	49	15	1.6
98RME-0051	35	241	165	<7	91	<35	<8	<6	13	0.12	<3	132	174	NA	2.3	NA	56	16	1.8
98RME-0053	41	232	102	<7	97	<35	<8	<6	11	0.18	<3	96	120	NA	1.5	NA	38	12	1.1
98RME-0074	29	399	115	12	96	<35	<8	<6	19	0.20	3	205	303	NA	1.4	NA	50	11	0.8
96RME-0213	26	160	31	9	74	<35	<8	<6	13	NA	<3	193	272	NA	3.0	NA	62	17	<10
98RME-0023	31	538	158	<7	82	<35	<8	<6	21	0.51	4	200	302	NA	1.1	NA	34	9	0.6
98RME-0025	21	116	105	<7	59	<35	<8	<6	3	0.01	<3	115	354	NA	0.8	NA	28	7	0.6
98RME-0030	45	241	171	<7	84	<35	<8	<6	9	0.42	<3	131	117	NA	1.4	NA	39	12	1.0
98RME-0031	11	64	9	22	44	<35	10	<6	43	3.08	<3	407	625	NA	1.2	NA	21	6	1.3
98RME-0050	25	221	64	10	103	<35	<8	<6	69	0.81	<3	456	314	NA	4.4	NA	92	16	5.2
98RME-0052	43	243	172	<7	93	<35	<8	<6	9	0.38	<3	115	126	NA	1.4	NA	40	12	1.0
98RME-0062	38	211	82	<7	81	<35	<8	<6	9	0.42	<3	93	116	NA	0.7	NA	38	11	0.9
96RME-0049	7	12	6	18	142	<35	9	<6	178	NA	<3	1845	120	NA	34.0	NA	733	99	19.0
96RME-0451	6	6	7	26	110	<35	<8	<6	96	3.30	<3	1100	140	1.10	22.0	6.00	490	65	19.0
96RME-0454	6	7	20	28	160	<35	<8	<6	180	2.80	3	1500	120	2.10	38.0	14.0	690	110	20.0
96RME-0461	11	20	6	19	100	<35	<8	<6	130	0.30	<3	990	210	0.95	15.0	4.90	280	42	13.0
96RME-0602	9	20	20	16	120	<35	<8	<6	120	0.32	3	1300	140	1.90	36.0	10.0	650	110	19.0
96RME-0606	10	10	5	17	42	<35	<8	<6	90	1.60	<3	970	160	1.50	26.0	6.20	440	67	19.0
96RME-3008	8	6	8	29	83	<35	<8	<6	65	0.85	<3	1200	130	1.70	27.0	9.10	480	67	21.0
96RME-3015	16	150	40	16	120	<35	<8	<6	100	5.90	<3	1100	380	0.73	12.0	3.90	190	20	8.8
96RME-3022	12	10	20	16	110	<35	<8	<6	110	4.00	<3	1100	150	1.50	24.0	5.10	420	69	19.0
96RME-3026	6	6	9	18	140	<35	<8	<6	140	1.10	3	1400	110	2.00	36.0	14.0	640	100	19.0
96RME-3036	2	10	7	17	30	<35	<8	<6	140	0.91	<3	1500	120	2.20	41.0	1.20	790	79	21.0

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	U	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
96RME-0041	NA	4.90	11.04	1.44	5.77	1.35	0.21	1.47	0.25	1.53	0.34	1.03	0.15	0.97	0.15
96RME-0267	NA	4.55	10.50	1.34	5.52	1.25	0.24	1.39	0.23	1.05	0.32	0.96	0.14	0.89	0.15
96RME-0341	0.4	4.80	11.00	1.40	6.00	1.30	0.35	1.50	0.23	1.40	0.30	0.90	0.13	0.94	0.15
97RME-0033	0.6	9.17	19.22	2.32	9.46	2.00	0.58	1.98	0.33	2.18	0.45	1.38	0.21	1.24	0.20
97RME-0035	0.4	5.81	13.41	1.74	7.14	1.55	0.47	1.57	0.26	1.76	0.36	1.16	0.16	1.13	0.17
97RME-0036	0.9	18.98	42.74	5.27	21.70	4.38	1.06	3.58	0.52	3.19	0.58	1.66	0.22	1.42	0.21
97RME-0037	0.9	15.44	36.33	4.94	21.31	4.59	1.31	4.00	0.60	3.71	0.69	2.04	0.28	1.76	0.26
98RME-0049	0.9	16.75	41.13	5.21	22.05	4.65	1.20	3.96	0.56	3.43	0.62	1.88	0.24	1.58	0.23
98RME-0055	0.3	13.67	35.07	4.74	19.81	4.03	1.20	3.41	0.49	2.93	0.53	1.52	0.20	1.24	0.19
H98-103	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-110	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-120	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-202	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-300	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-317	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-401	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-406	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-408	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
H98-409	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
96RME-0200	NA	2.35	5.62	0.80	3.62	1.07	0.36	1.38	0.24	1.65	0.36	1.05	0.16	1.01	0.16
96RME-0457	0.9	17.00	33.00	3.90	15.00	3.20	0.78	3.40	0.56	3.40	0.72	2.10	0.29	2.00	0.31
96RME-0460	0.6	9.40	19.00	2.30	9.00	2.00	0.64	2.30	0.35	2.20	0.45	1.40	0.19	1.30	0.21
98RME-0022	0.8	19.79	40.88	5.11	20.98	4.58	1.33	4.64	0.72	4.80	1.01	2.95	0.42	2.80	0.43
98RME-0024	0.1	3.28	6.82	0.90	4.01	1.00	0.42	1.16	0.21	1.43	0.29	0.90	0.13	0.91	0.14
98RME-0027	0.3	4.19	8.77	1.19	5.37	1.44	0.48	1.72	0.30	1.97	0.43	1.31	0.18	1.30	0.20
98RME-0038	0.3	3.85	7.85	1.04	4.66	1.25	0.42	1.48	0.26	1.76	0.38	1.13	0.16	1.13	0.17
98RME-0047	0.4	4.67	9.84	1.27	5.54	1.47	0.53	1.76	0.30	2.00	0.43	1.29	0.18	1.24	0.19
98RME-0048	0.4	6.27	12.93	1.62	6.84	1.79	0.60	2.13	0.35	2.38	0.50	1.49	0.22	1.48	0.23
98RME-0051	0.5	6.85	14.05	1.77	7.74	1.92	0.62	2.33	0.39	2.54	0.53	1.60	0.24	1.62	0.26
98RME-0053	0.3	4.53	8.92	1.14	4.92	1.34	0.48	1.59	0.28	1.88	0.40	1.19	0.17	1.22	0.17
98RME-0074	0.2	5.30	11.14	1.42	6.09	1.46	0.58	1.58	0.26	1.81	0.39	1.14	0.16	1.10	0.18
96RME-0213	NA	8.69	19.47	2.52	10.26	2.35	0.93	2.48	0.41	2.52	0.56	1.65	0.25	1.57	0.24
98RME-0023	0.1	3.79	7.98	1.03	4.56	1.11	0.51	1.21	0.21	1.38	0.28	0.88	0.12	0.85	0.13
98RME-0025	0.1	3.49	7.17	0.92	4.00	0.95	0.37	1.04	0.16	1.16	0.24	0.75	0.11	0.73	0.11
98RME-0030	0.3	3.90	8.26	1.09	4.87	1.29	0.43	1.58	0.27	1.90	0.40	1.22	0.17	1.20	0.18
98RME-0031	0.6	1.59	4.62	0.63	2.84	0.82	0.42	0.90	0.15	0.95	0.21	0.57	0.08	0.53	0.07
98RME-0050	0.6	17.96	36.95	4.44	17.28	3.27	0.80	2.78	0.41	2.69	0.53	1.57	0.21	1.38	0.22
98RME-0052	0.3	4.01	8.55	1.12	5.01	1.32	0.47	1.58	0.28	1.88	0.42	1.24	0.18	1.20	0.18
98RME-0062	0.2	3.75	7.96	1.05	4.61	1.29	0.44	1.53	0.26	1.90	0.40	1.17	0.17	1.14	0.18
96RME-0049	NA	96.24	382.73	25.72	97.77	20.10	3.62	19.56	3.31	19.87	4.31	12.69	1.93	12.61	1.98
96RME-0451	1.7	77.00	>250	19.00	70.00	13.00	2.10	13.00	2.00	11.00	2.40	7.00	0.97	6.40	0.93
96RME-0454	3.2	83.00	>250	22.00	81.00	17.00	3.30	18.00	3.10	19.00	4.10	12.00	1.80	12.00	1.90
96RME-0461	2.6	41.00	95.00	11.00	41.00	8.90	2.00	8.50	1.30	7.60	1.60	4.60	0.63	4.10	0.60
96RME-0602	2.3	91.00	>250	23.00	87.00	18.00	3.30	18.00	3.10	18.00	3.90	12.00	1.70	11.00	1.70
96RME-0606	3.5	67.00	170.00	16.00	60.00	12.00	2.50	12.00	2.00	11.00	2.40	6.90	0.98	6.30	0.95
96RME-3008	3.7	52.00	130.00	13.00	49.00	10.00	2.10	11.00	1.90	12.00	2.60	7.80	1.20	7.70	1.10
96RME-3015	2.4	46.00	93.00	11.00	40.00	7.00	1.80	6.00	0.83	4.20	0.74	2.20	0.30	1.90	0.30
96RME-3022	3.4	72.00	200.00	17.00	64.00	13.00	2.60	13.00	2.10	12.00	2.60	7.60	1.10	7.00	1.10
96RME-3026	2.7	69.00	230.00	18.00	69.00	16.00	3.10	16.00	2.90	18.00	4.00	12.00	1.90	12.00	1.80
96RME-3036	3.0	110.00	>250	27.00	100.00	20.00	4.10	20.00	3.00	16.00	3.10	9.50	1.50	10.00	1.60

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	Easting	Northing	Rock Type	Map Unit	SiO_2	TiO_2	Al_2O_3	$Fe_2O_3^*$	Fe_2O_3	FeO	MnO	MgO
96RME-0123	532820	5162930	Mafic metvolcanic	10	54.75	0.75	14.87	11.13	2.59	7.68	0.17	4.74
96RME-0233	531900	5162120	Amphibolite	10	52.36	1.40	13.88	15.98	2.61	12.03	0.18	4.77
96RME-0447	532760	5162995	Mafic metavolcanic	10	49.20	1.04	13.93	14.11	3.00	10.00	0.22	6.59
96RME-3004	532009	5162502	Mafic metavolcanic	10	50.62	2.17	13.74	16.58	2.13	13.00	0.25	4.53
96RME-0124	532849	5162892	Felsic metavolcanic	11	66.42	0.72	12.95	7.24	2.93	3.88	0.10	1.10
96RME-0448	532820	5162800	Felsic metavolcanic	11	61.58	1.22	12.48	11.41	3.19	7.40	0.14	1.36
96RME-3005	531950	5162255	Conglomerate	11	56.09	1.30	14.41	10.58	1.02	8.60	0.08	3.75
96RME-0183	527529	5154663	Bi-ky schist	12	59.19	1.29	17.52	7.99	0.78	6.49	0.08	2.11
96RME-0184	527529	5154663	Meta-arenite	12	73.82	0.46	12.38	3.67	0.65	2.72	0.04	0.91
96RME-0234	531930	5162020	Schist	12	64.01	0.86	16.19	6.46	1.46	4.50	0.07	2.34
96RME-0242	531900	5161900	Ky schist	12	60.86	0.99	17.67	8.19	1.19	6.30	0.07	3.32
96RME-0092	531060	5162100	Miss siltstone	13	77.65	0.36	9.34	3.70	1.10	2.34	<0.01	1.60
96RME-0122	532680	5163500	Sheared Mississagi	13	85.05	0.17	6.99	1.84	1.17	0.60	<0.01	0.88
96RME-3001	531359	5162477	Miss sandstone	13	82.99	0.31	6.72	3.10	0.66	2.20	<0.01	1.76
96RME-3040	532900	5162310	Sheared Mississagi	13	82.52	0.15	7.11	1.24	0.64	0.54	<0.01	0.75
96RME-3030	531960	5162357	atypical Mississagi	13	72.23	0.63	10.63	5.56	1.34	3.80	0.03	2.39
96RME-3031	531900	5162260	atypical Mississagi	13	59.21	1.03	15.32	9.46	1.68	7.00	0.09	3.06
96RME-3002	531359	5162477	Bruce Fm	14	68.98	0.56	12.61	5.30	1.41	3.50	0.02	3.35
96RME-0446	532980	5162960	Nip gabbro (NGF)	18	49.90	0.48	14.85	9.46	1.79	6.90	0.14	7.86
96RME-0449	532668	5162632	Nip gabbro (NGF)	18	56.97	0.97	13.63	12.20	2.86	8.40	0.18	3.47
96RME-0610	532053	5163742	Nip gabbro (NGF)	18	51.40	0.38	13.85	8.67	1.78	6.20	0.17	10.60
96RME-1056	529260	5159000	Amphibolite	18	49.83	0.35	14.49	7.67	1.20	5.82	0.14	10.45
96RME-3006	532081	5162398	Nip gabbro (NGF)	18	49.64	1.00	14.29	13.43	2.54	9.80	0.21	7.22
96RME-3147	532900	5162840	Nip gabbro (NGF)	18	50.41	0.35	14.97	7.57	1.35	5.60	0.13	9.44
96RME-3148	533000	5162870	Nip gabbro (NGF)	18	52.30	1.68	13.62	14.28	3.17	10.00	0.18	3.72
96RME-3151	532120	5162420	Nip gabbro (NGF)	18	55.94	0.88	13.68	11.57	3.12	7.60	0.17	4.30
96RME-0082	530342	5158175	Meta Sudury dike	20	47.26	2.45	18.82	11.90	2.57	8.39	0.17	2.45
97RME-0039	524300	5150250	Meta dike	20	45.56	2.80	16.03	16.03	2.51	11.63	0.23	5.57
96RME-0499	491500	5146000	McKim metapelite		55.65	0.96	22.99	7.12	0.90	5.60	0.04	2.21
86RLD-0203			Stobie dacite	10	69.69	0.62	12.30	5.28	2.17	2.80	0.05	1.09
86RLD-1902			Stobie basalt	11	46.35	1.02	17.24	13.86	3.64	9.20	0.18	4.77
86RLD-5302			CCF rhyolite		75.46	0.15	11.75	1.60	0.38	1.10	0.02	0.14
86RLD-0402			Miss subarkose	13	85.69	0.15	6.48	1.22	0.51	0.64	<0.01	0.93
86RLD-0801			Miss arkose	13	76.60	0.26	9.49	3.11	2.67	0.40	<0.01	0.78
86RLD-0805			Miss subarkose	13	86.61	0.12	6.95	0.90	0.46	0.40	<0.01	0.52
86RLD-0905			Miss wacke	13	87.20	0.18	6.40	1.10	0.61	0.44	<0.01	0.56
86RLD-1104			Bruce wacke	14	64.80	0.58	13.79	6.08	1.63	4.00	0.04	3.55
86RLD-1701			Espanola siltstone	15	64.29	0.41	12.95	3.68	0.79	2.60	0.02	3.28
86RLD-2904			Espanola siltstone	15	61.73	0.06	15.01	5.65	1.76	3.50	<0.01	4.74
86RLD-3002			Serpent arkose	16	75.57	0.11	11.52	1.29	0.39	0.81	<0.01	1.40
86RLD-3408			Alt Espanola arkose	15	41.50	0.53	11.37	3.46	0.68	2.50	0.08	6.70
86RLD-3703			Pecors siltstone	12	62.09	0.83	17.72	6.28	1.72	4.10	0.04	2.72
86RLD-3902			Miss siltstone	13	59.04	0.75	20.85	3.39	2.06	1.20	0.02	1.98
86RLD-5102			Pecors siltstone	12	64.79	0.70	15.51	6.19	1.08	4.60	0.04	2.94
86RLD-5201			Granite (Nipissing?)		82.10	0.12	10.90	0.18	0.08	<0.01	<0.01	0.07
86RLD-5501			McKim wacke		85.20	0.26	6.31	2.14	0.58	1.40	<0.01	1.34

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucvovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	CaO	Na_2O	K_2O	P_2O_5	H_2O^-	CO_2	S	LOI	Total	Mg No.	CIA	PIA	Cr	Ni	Co
96RME-0123	8.72	2.39	1.30	0.12	0.17	0.18	<0.01	1.04	99.97	45.8	54.9	9.6	81	77	38
96RME-0233	9.37	1.26	0.85	0.15	0.18	0.13	0.11	0.62	100.82	37.2	55.0	10.3	38	65	49
96RME-0447	10.51	1.85	0.52	0.06	0.26	0.14	0.08	1.14	99.17	48.0	52.2	11.9	120	81	50
96RME-3004	7.33	2.14	0.95	0.17	0.23	0.14	0.21	1.02	99.50	35.1	57.2	9.4	63	73	50
96RME-0124	2.46	3.16	3.57	0.15	0.41	0.15	0.12	1.40	99.28	23.1	58.9	-11.1	38	16	10
96RME-0448	4.44	2.67	3.08	0.17	0.25	0.10	0.04	0.83	99.38	19.1	55.3	-6.3	5	9	30
96RME-3005	2.61	2.72	2.88	0.22	0.27	0.12	0.02	3.87	98.51	41.2	64.0	-2.8	86	60	30
96RME-0183	0.95	2.50	5.75	0.20	0.17	0.14	<0.01	0.70	98.28	34.3	65.9	-20.6	90	18	10
96RME-0184	0.72	2.70	4.08	0.07	0.14	0.14	<0.01	0.48	99.33	32.9	62.7	-22.9	27	14	9
96RME-0234	1.98	2.87	2.50	0.10	0.28	0.11	<0.01	1.23	98.61	41.8	69.1	2.6	120	50	20
96RME-0242	1.31	1.70	2.85	0.12	0.30	0.16	0.02	1.35	98.43	44.5	75.6	1.5	210	58	20
96RME-0092	0.11	1.94	2.36	0.04	0.34	0.18	0.14	1.79	98.89	46.1	68.8	-17.3	47	50	12
96RME-0122	0.03	0.59	2.42	0.03	0.39	0.13	0.02	1.61	99.60	48.7	70.6	-40.8	44	12	4
96RME-3001	0.09	2.59	0.01	-0.01	0.21	0.11	0.08	1.43	98.99	52.9	72.3	6.6	120	40	10
96RME-3040	0.02	1.17	2.35	-0.01	0.28	0.16	0.03	3.50	98.80	54.5	67.8	-33.5	40	10	<5
96RME-3030	0.91	1.24	3.13	0.10	0.34	0.38	0.01	1.54	98.39	46.0	68.4	-23.1	41	30	10
96RME-3031	2.50	2.95	3.40	0.15	0.31	0.22	0.05	1.31	98.48	39.0	64.0	-4.5	140	54	29
96RME-3002	0.08	1.47	2.50	0.04	0.49	0.21	0.01	3.82	98.73	55.6	76.7	-9.2	210	30	<5
96RME-0446	8.34	1.99	1.32	-0.01	0.29	1.30	0.02	4.45	98.78	62.2	58.9	9.0	240	110	40
96RME-0449	7.20	2.65	1.53	0.08	0.20	0.14	0.03	0.74	99.62	36.0	54.8	6.6	16	30	40
96RME-0610	13.23	1.21	0.34	-0.01	0.20	0.11	0.01	0.38	100.22	70.8	48.6	12.6	740	170	40
96RME-1056	13.62	1.17	0.50	0.03	0.15	0.16	<0.01	1.24	99.49	73.0	48.9	12.7	981	170	35
96RME-3006	10.32	2.11	0.54	0.05	0.18	0.08	0.04	0.81	99.62	51.6	52.6	12.2	180	110	50
96RME-3147	11.29	2.59	0.55	0.00	0.23	0.11	<0.01	1.63	98.93	71.2	51.1	13.0	750	140	40
96RME-3148	6.80	2.63	2.20	0.12	0.33	0.15	0.02	1.88	99.41	34.0	54.3	3.0	17	20	40
96RME-3151	7.07	2.40	2.21	0.08	0.20	0.08	<0.01	1.28	99.58	42.4	54.1	3.1	30	50	40
96RME-0082	8.00	4.68	1.74	1.00	0.16	0.14	0.11	0.10	98.57	29.0	56.9	12.9	10	27	29
97RME-0039	8.87	2.74	0.91	0.47	0.18	0.07	0.04	0.45	99.66	39.9	56.3	12.6	187	120	55
96RME-0499	0.87	1.00	3.60	0.04	0.42	0.26	0.07	4.28	98.76	38.1	81.5	5.8	190	84	30
86RLD-0203	2.43	3.39	2.99	0.14	0.12	0.20	<0.01	0.91	98.89	58.8	29.21	10	11	9	11
86RLD-1902	11.69	0.21	0.31	0.06	0.18	0.70	0.04	3.65	99.34	60.0	41.17	150	70	33	36
86RLD-5302	0.64	2.90	5.28	<0.01	0.08	0.30	<0.01	0.55	98.49	58.0	1.18	6	<5	<5	2
86RLD-0402	0.05	2.73	0.46	<0.01	0.06	0.06	0.07	0.78	98.49	60.1	67.1	1.2	51	9	<5
86RLD-0801	0.07	3.72	1.41	<0.01	0.31	0.20	<0.01	1.22	96.66	33.2	65.5	-2.6	46	30	<5
86RLD-0805	0.06	3.03	0.78	<0.01	0.11	0.33	0.06	0.66	99.63	53.2	66.3	-1.8	34	18	<5
86RLD-0905	0.16	1.24	1.88	0.02	0.05	0.10	0.00	0.00	98.74	50.2	66.8	-25.9	NA	NA	NA
86RLD-1104	1.86	4.12	2.21	0.05	0.16	0.34	0.15	1.10	98.18	53.6	63.7	1.0	220	59	19
86RLD-1701	3.36	6.02	0.35	0.04	0.06	2.60	0.17	3.78	98.18	63.8	64.5	11.1	100	52	21
86RLD-2904	0.46	6.59	1.92	0.06	0.11	0.44	0.19	1.19	97.41	62.4	63.8	5.3	130	92	19
86RLD-3002	0.63	4.79	1.88	<0.01	0.09	0.71	<0.01	1.31	98.50	68.2	63.6	-1.6	34	15	<5
86RLD-3408	11.64	6.68	0.09	0.04	0.10	17.00	0.06	17.39	99.48	79.3	89.0	10.7	130	42	<5
86RLD-3703	1.07	1.36	4.34	0.03	0.13	0.01	0.46	2.73	99.21	46.2	72.4	-9.7	260	110	32
86RLD-3902	0.35	0.72	7.97	<0.01	0.20	0.20	0.01	3.12	98.19	53.6	70.2	-37.1	210	21	<5
86RLD-5102	1.10	1.72	2.47	0.03	0.10	0.01	0.07	2.69	98.18	48.5	74.6	-0.1	230	90	24
86RLD-5201	0.43	4.27	0.52	0.02	0.04	0.26	<0.01	0.55	99.16	43.8	68.7	7.4	5	<5	<5
86RLD-5501	0.24	2.09	0.41	<0.01	0.09	0.20	0.02	1.12	99.11	55.4	71.3	1.2	76	30	<5

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucvovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	Sc	V	Cu	Pb	Zn	W	Mo	As	Rb	Cs	Be	Ba	Sr	Ta	Nb	Hf	Zr	Y	Th
96RME-0123	24	150	83	12	90	<35	<8	<6	41	NA	<3	413	171	NA	10.0	NA	176	37	<10
96RME-0233	36	360	180	13	140	<35	<8	<6	19	NA	3	175	377	NA	7.0	NA	143	39	<10
96RME-0447	36	290	150	<7	91	<35	<8	<6	16	0.06	<3	210	180	0.39	5.0	0.34	99	31	2.1
96RME-3004	31	370	290	12	160	<35	<8	<6	28	0.63	4	440	150	0.90	12.0	3.70	210	46	11.0
96RME-0124	11	31	12	23	98	<35	<8	<6	96	NA	<3	1070	160	NA	23.0	NA	434	69	18.0
96RME-0448	18	95	10	16	110	<35	<8	<6	99	3.50	<3	880	200	1.30	20.0	1.50	330	61	15.0
96RME-3005	14	170	50	18	120	<35	<8	<6	100	9.80	<3	1000	760	0.83	15.0	3.70	220	24	7.8
96RME-0183	6	54	4	16	31	<35	<8	<6	189	NA	<3	1671	148	NA	19.0	NA	364	39	15.0
96RME-0184	5	31	4	9	30	<35	<8	<6	99	NA	<3	1102	133	NA	8.0	NA	216	21	<10
96RME-0234	12	120	40	23	75	<35	<8	<6	97	6.90	<3	1100	600	0.50	5.9	4.00	190	17	8.1
96RME-0242	16	140	30	22	100	<35	<8	12	110	6.50	<3	880	250	0.41	5.2	4.80	180	33	9.4
96RME-0092	4	44	47	<7	31	<35	9	<6	86	NA	<3	454	70	NA	5.0	NA	65	6	<10
96RME-0122	3	26	16	8	16	<35	<8	<6	72	NA	<3	281	28	NA	3.0	NA	63	7	<10
96RME-3001	4	30	30	<7	20	<35	<8	14	7	0.27	<3	58	53	0.12	1.4	1.70	120	10	4.8
96RME-3040	3	20	10	<7	10	<35	<8	<6	69	1.10	<3	330	43	0.31	2.7	1.20	56	8	3.6
96RME-3030	8	82	9	12	68	<35	<8	<6	97	8.00	<3	1900	310	0.61	9.5	3.80	170	11	7.0
96RME-3031	16	170	40	16	120	<35	<8	<6	110	3.00	<3	1500	380	0.77	13.0	1.60	180	17	7.7
96RME-3002	14	120	20	<7	40	<35	<8	26	92	2.70	<3	330	38	0.24	3.1	2.90	160	13	6.6
96RME-0446	31	190	50	10	72	<35	<8	24	51	0.87	<3	320	120	0.23	1.8	0.64	41	15	1.0
96RME-0449	25	240	50	11	100	<35	<8	<6	45	0.77	<3	500	210	0.85	12.0	0.88	200	43	8.8
96RME-0610	35	180	58	<7	56	<35	<8	<6	10	0.51	<3	93	120	0.12	1.3	0.85	36	13	0.9
96RME-1056	37	190	35	7	55	<35	10	<6	10	NA	<3	71	110	NA	2.9	NA	29	12	<10
96RME-3006	33	270	150	7	100	<35	<8	<6	13	0.15	<3	200	140	0.29	4.6	0.59	88	27	1.8
96RME-3147	26	140	10	10	60	<35	<8	<6	11	0.13	<3	310	200	0.23	3.1	0.43	68	17	2.4
96RME-3148	27	380	20	8	120	<35	<8	<6	65	0.39	4	760	190	0.79	13.0	1.70	200	43	7.7
96RME-3151	25	210	72	7	100	<35	<8	<6	69	0.85	<3	600	180	0.74	12.0	2.30	190	39	8.7
96RME-0082	14	95	37	11	120	<35	<8	<6	37	NA	<3	1035	676	NA	31.0	NA	348	51	<10
97RME-0039	32	297	340	27	166	<35	<8	<6	31	0.80	4	295	248	NA	13.8	NA	234	45	4.7
96RME-0499	20	170	67	23	110	<35	<8	25	160	4.00	4	760	280	0.97	11.0	4.70	170	31	20.0
86RLD-0203	38	53	42	43	<8	7	<8	<6	110	1.40	<3	960	220	0.91	14.0	4.60	260	31	11.0
86RLD-1902	330	160	63	120	<8	11	<8	<6	9	0.74	<3	130	350	0.29	4.6	0.89	88	31	1.7
86RLD-5302	<5	15	37	36	<8	<6	<8	<6	230	4.10	4	900	50	2.70	36.0	7.70	210	33	31.0
86RLD-0402	3	20	<5	26	16	<35	<8	<6	19	0.25	<3	130	57	0.06	0.6	1.20	55	8	3.9
86RLD-0801	4	36	35	49	13	<35	<8	<6	42	0.93	<3	280	58	0.31	3.4	2.60	120	9	4.8
86RLD-0805	2	16	19	43	10	<35	<8	<6	32	0.77	<3	220	89	0.14	1.5	0.94	43	6	1.9
86RLD-0905	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
86RLD-1104	13	120	32	8	54	<35	<8	<6	92	2.40	<3	60	230	0.54	6.8	3.40	140	11	7.7
86RLD-1701	9	73	6	<7	16	<35	9	7	27	0.90	<3	74	110	0.32	3.8	3.80	150	20	9.3
86RLD-2904	15	130	8	<7	21	<35	8	6	160	4.20	<3	270	89	1.00	12.0	5.10	180	22	15.0
86RLD-3002	2	18	5	9	10	<35	9	<6	45	0.84	<3	480	190	0.16	1.6	1.00	48	9	2.0
86RLD-3408	12	88	8	23	20	<35	10	6	5	0.06	<3	47	49	0.25	3.1	3.30	120	14	9.1
86RLD-3703	19	160	100	19	94	<35	12	<6	140	9.30	<3	1500	200	0.71	9.3	3.60	150	22	8.6
86RLD-3902	15	140	15	46	30	<35	13	<6	>700	4.20	<3	1600	60	1.80	15.0	4.20	170	12	9.2
86RLD-5102	15	120	38	40	110	<35	10	13	93	2.70	<3	680	140	0.87	10.0	5.10	200	20	12.0
86RLD-5201	1	<5	9	10	6	<35	<8	<6	4	0.39	<3	92	32	11.0	2.0	2.20	58	5	14.0
86RLD-5501	5	41	70	23	25	<35	<8	<6	19	1.10	<3	190	57	0.34	3.1	3.20	130	6	17.0

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = muevovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 1. Listing by map unit of geochemical data collected during this study — continued.

Sample Name	U	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
96RME-0123	NA	27.70	57.45	7.01	26.30	5.73	1.33	5.70	0.95	5.82	1.23	3.56	0.52	3.30	0.48
96RME-0233	NA	13.32	30.67	4.10	17.17	4.63	1.36	5.43	0.96	6.07	1.34	3.99	0.59	3.76	0.59
96RME-0447	0.5	13.00	28.00	3.60	15.00	3.70	1.10	4.20	0.72	4.30	0.95	2.80	0.39	2.50	0.38
96RME-3004	2.9	26.00	57.00	7.10	27.00	6.50	1.60	7.10	1.20	7.30	1.60	4.60	0.64	4.20	0.64
96RME-0124	NA	59.59	146.86	15.57	58.67	12.06	2.30	11.32	1.88	11.51	2.48	7.37	1.10	6.77	0.99
96RME-0448	3.1	55.00	110.00	13.00	51.00	10.00	2.20	11.00	1.70	10.00	2.10	6.20	0.89	5.60	0.83
96RME-3005	1.2	45.00	95.00	11.00	41.00	7.70	2.10	6.70	0.94	4.80	0.85	2.50	0.31	2.10	0.31
96RME-0183	NA	56.99	123.56	15.53	57.95	10.80	2.35	8.53	1.23	6.23	1.28	3.76	0.57	3.80	0.59
96RME-0184	NA	33.58	74.55	9.04	33.53	6.02	1.57	4.55	0.64	3.34	0.70	2.09	0.31	2.00	0.31
96RME-0234	2.5	40.00	83.00	9.50	34.00	5.80	1.70	4.80	0.64	3.20	0.55	1.60	0.20	1.40	0.22
96RME-0242	3.3	41.00	87.00	10.00	38.00	6.80	1.70	5.70	0.78	4.00	0.68	2.00	0.26	1.90	0.29
96RME-0092	NA	2.09	4.86	0.60	2.21	0.45	0.16	0.42	0.07	0.44	0.09	0.28	0.04	0.32	0.05
96RME-0122	NA	4.42	10.11	1.18	4.26	0.74	0.23	0.55	0.07	0.42	0.08	0.24	0.03	0.28	0.05
96RME-3001	1.9	5.30	12.00	1.50	5.70	1.20	0.25	1.10	0.14	0.79	0.15	0.51	0.06	0.54	0.09
96RME-3040	2.0	9.40	20.00	2.40	8.90	1.60	0.45	1.20	0.17	0.79	0.11	0.34	0.04	0.37	0.06
96RME-3030	1.5	9.30	22.00	1.90	6.40	1.10	0.80	1.00	0.18	1.20	0.28	1.10	0.18	1.40	0.21
96RME-3031	1.3	18.00	28.00	2.90	9.60	1.70	0.89	1.40	0.25	1.80	0.55	2.10	0.33	2.30	0.34
96RME-3002	3.7	19.00	43.00	5.20	20.00	3.70	0.83	2.80	0.34	1.50	0.24	0.82	0.10	0.87	0.16
96RME-0446	0.3	4.20	9.40	1.20	5.20	1.40	0.51	1.70	0.30	1.90	0.43	1.20	0.18	1.20	0.18
96RME-0449	2.0	32.00	66.00	7.90	30.00	6.50	1.60	6.90	1.10	6.70	1.40	4.20	0.60	3.90	0.59
96RME-0610	0.3	3.40	7.60	1.00	4.40	1.20	0.40	1.50	0.25	1.60	0.36	1.10	0.14	1.00	0.16
96RME-1056	0.0	2.38	5.15	0.72	3.12	0.93	0.35	1.23	0.21	1.45	0.32	0.96	0.14	0.88	0.13
96RME-3006	0.4	8.80	20.00	2.70	12.00	3.10	1.00	3.90	0.67	4.10	0.95	2.80	0.40	2.70	0.41
96RME-3147	0.6	9.30	19.00	2.40	9.50	2.20	0.69	2.50	0.42	2.50	0.56	1.60	0.23	1.50	0.23
96RME-3148	1.8	29.00	62.00	7.60	29.00	6.70	1.90	7.10	1.20	7.20	1.50	4.40	0.66	4.30	0.66
96RME-3151	2.0	32.00	67.00	8.00	30.00	6.60	1.60	6.90	1.10	6.80	1.40	4.20	0.62	4.00	0.60
96RME-0082	NA	46.26	107.77	14.88	61.94	12.83	3.84	11.11	1.67	9.00	1.78	4.87	0.69	4.31	0.65
97RME-0039	1.0	21.01	48.36	6.31	28.18	7.04	2.01	7.27	1.13	7.41	1.49	4.42	0.62	4.04	0.62
96RME-0499	6.0	51.00	100.00	11.00	41.00	7.50	1.70	6.70	0.98	5.20	0.94	2.70	0.34	2.50	0.38
86RLD-0203	2.7	35.00	75.00	8.90	34.00	6.50	1.50	6.20	0.96	5.50	1.10	3.40	0.48	3.10	0.44
86RLD-1902	0.4	14.00	27.00	3.50	15.00	3.80	1.50	4.90	0.78	5.00	1.00	3.10	0.42	2.60	0.38
86RLD-5302	4.7	49.00	96.00	11.00	36.00	6.10	0.79	5.60	0.93	5.70	1.20	4.60	0.79	6.10	0.99
86RLD-0402	1.1	8.40	18.00	2.20	8.10	1.40	0.21	1.10	0.13	0.60	0.09	0.28	0.04	0.31	0.04
86RLD-0801	1.1	5.40	15.00	1.50	5.40	1.20	0.42	1.20	0.20	1.30	0.25	0.72	0.10	0.74	0.10
86RLD-0805	0.7	3.60	8.00	0.95	3.70	0.70	0.22	0.73	0.07	0.54	0.10	0.35	0.04	0.36	0.05
86RLD-0905	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
86RLD-1104	1.9	10.00	24.00	3.10	12.00	2.30	0.62	1.80	0.27	1.60	0.32	1.10	0.16	1.20	0.19
86RLD-1701	3.5	35.00	67.00	7.80	29.00	5.00	0.87	4.00	0.52	2.50	0.47	1.50	0.23	1.60	0.24
86RLD-2904	5.4	6.40	18.00	2.10	8.60	2.20	0.79	2.60	0.47	3.40	0.71	2.30	0.33	2.20	0.34
86RLD-3002	0.7	30.00	64.00	7.90	29.00	4.20	0.82	2.80	0.32	1.20	0.19	0.53	0.06	0.50	0.08
86RLD-3408	2.9	3.20	7.00	0.95	4.30	1.20	0.35	1.50	0.23	1.40	0.26	0.81	0.12	0.93	0.14
86RLD-3703	2.9	26.00	55.00	6.60	25.00	4.80	1.30	4.60	0.68	3.90	0.77	2.30	0.34	2.20	0.33
86RLD-3902	7.4	1.70	7.70	0.64	2.70	0.79	0.56	1.00	0.19	1.60	0.40	1.50	0.28	2.10	0.34
86RLD-5102	4.5	33.00	67.00	7.90	29.00	5.20	1.20	4.50	0.65	3.50	0.69	2.10	0.30	2.10	0.32
86RLD-5201	1.9	20.00	45.00	4.00	12.00	1.80	0.21	1.80	0.17	0.67	0.09	0.26	0.03	0.29	0.00
86RLD-5501	3.3	6.10	13.00	1.40	4.82	0.82	0.12	0.71	0.10	0.64	0.13	0.44	0.06	0.53	0.09

NA = not analyzed. Abbreviations: ath = anthophyllite; bi = biotite; CCF = Cooper Cliff Formation; CIA = chemical index of alteration; gd = gedrite; grt = garnet; hb = hornblende; ky = kyanite; Miss = Mississagi Formation; musc = mucovite; ol = olivine; opx = orthopyroxene; NGF = North of Grenville Front boundary fault; Nip = Nipssing; PIA = plagioclase index of alteration; plag = plagioclase.

Appendix 2:

Listing of Chemical Analyses from the Literature Relevant to this Study

Appendix 2. Listing of chemical analyses from the literature relevant to this study.

Sample No.	Source	Rock Type	SiO_2	TiO_2	Al_2O_3	Fe_2O_3*	MnO	MgO	CaO	Na_2O	K_2O
LN96-chill	Lightfoot & Naldrett 1996	Nipissing gabbro, average chill margin	51.62	0.69	13.42	11.83	0.21	8.81	9.63	2.06	0.73
LN96-gabbro	Lightfoot & Naldrett 1996	Nipissing gabbro, average gabbro	51.81	0.65	14.47	11.43	0.19	8.10	10.02	2.12	0.87
LT-H17	La Tour 1979	N amphibolite	50.52	0.33	13.99	9.01	0.15	10.83	11.32	1.11	0.68
LT-H24	La Tour 1979	N amphibolite	50.20	0.39	14.27	7.80	0.14	9.86	12.60	1.58	0.37
LT-C208	La Tour 1979	N amphibolite	49.71	0.20	15.45	6.44	0.15	11.04	14.49	0.99	0.44
LT-S51	La Tour 1979	N amphibolite	49.29	0.24	17.81	7.07	0.12	9.52	12.23	1.32	0.75
LT-S52	La Tour 1979	N amphibolite	48.51	0.22	19.51	6.03	0.15	7.61	13.60	1.72	0.37
LT-C209	La Tour 1979	N amphibolite	49.19	0.39	17.00	9.18	0.17	7.71	10.84	1.95	1.20
LT-S59	La Tour 1979	N amphibolite	50.48	0.25	13.50	7.05	0.15	11.98	13.25	1.19	0.37
LT-C210	La Tour 1979	N amphibolite	49.74	0.25	13.36	7.16	0.16	12.15	12.59	0.93	0.77
LT-S63	La Tour 1979	N amphibolite	49.26	0.29	13.44	7.89	0.28	12.16	13.03	1.00	0.68
LT-S94	La Tour 1979	N amphibolite	49.93	0.31	13.84	8.69	0.17	12.06	14.24	0.50	0.30
LT-C211	La Tour 1979	N amphibolite	51.99	0.69	15.88	11.29	0.21	6.92	9.85	1.69	0.85
LT-S90	La Tour 1979	N amphibolite	53.73	1.10	13.76	13.50	0.21	4.77	8.12	1.64	0.94
LT-S70	La Tour 1979	N amphibolite	59.98	1.62	12.19	13.85	0.11	1.83	6.09	2.29	0.94
LT-S122	La Tour 1979	N amphibolite	49.97	0.22	14.20	6.73	0.16	11.83	14.03	0.75	0.40
LT-S168	La Tour 1979	N amphibolite	51.51	0.21	11.33	6.99	0.16	13.05	14.54	0.24	0.15
LT-S72	La Tour 1979	G amphibolite	46.01	3.23	13.33	18.37	0.22	4.77	9.00	1.52	2.10
LT-S102	La Tour 1979	G amphibolite	44.21	3.55	14.03	20.43	0.22	5.54	9.00	1.80	1.21
LT-S109	La Tour 1979	G amphibolite	46.90	2.19	13.06	16.81	0.25	6.68	9.90	2.00	0.97
LT-S112	La Tour 1979	G amphibolite	47.92	2.48	12.81	16.72	0.25	4.97	8.65	3.30	1.78
LT-S117	La Tour 1979	G amphibolite	49.26	1.64	13.23	16.96	0.23	5.81	9.55	1.58	1.10
LT-S126	La Tour 1979	G amphibolite	49.22	1.03	15.81	13.29	0.18	4.18	14.38	0.67	0.22
LT-S138	La Tour 1979	G amphibolite	47.76	1.91	13.22	15.89	0.22	6.28	9.50	2.95	1.32
LT-S141	La Tour 1979	G amphibolite	47.02	1.76	13.70	16.03	0.21	7.57	8.72	2.77	1.09
LT-S146	La Tour 1979	G amphibolite	51.93	1.52	14.50	15.45	0.19	4.87	8.57	1.22	0.99
LT-S151	La Tour 1979	G amphibolite	47.06	2.11	13.29	17.14	0.24	6.79	9.44	2.34	0.87
LT-S157	La Tour 1979	G amphibolite	48.03	1.37	15.80	14.58	0.17	6.44	8.78	2.44	0.82
LT-S159	La Tour 1979	G amphibolite	45.30	3.28	12.75	19.35	0.29	5.87	9.16	1.47	2.14
LT-C205	La Tour 1979	G amphibolite	46.67	2.42	14.00	16.05	0.24	6.21	8.82	2.01	1.01
LT-C206	La Tour 1979	G amphibolite	47.47	3.24	13.19	18.65	0.18	4.52	8.22	2.16	0.97
LT-S145	La Tour 1979	G amphibolite	45.98	3.01	12.29	18.82	NA	5.25	9.47	2.30	1.38
LT-S148	La Tour 1979	G amphibolite	54.04	1.99	13.21	17.24	NA	NA	7.65	2.20	1.14
LT-S149	La Tour 1979	G amphibolite	54.24	1.25	13.78	11.71	NA	5.76	7.13	2.07	3.47
LT-S163	La Tour 1979	G amphibolite	58.27	1.15	14.27	11.47	NA	3.30	7.18	2.40	0.83
LT-S165	La Tour 1979	G amphibolite	54.93	1.45	14.79	13.78	NA	3.65	6.94	2.35	1.87
LT-S41B	La Tour 1979	G amphibolite	55.14	1.62	13.93	13.98	NA	4.28	7.45	2.25	1.53
LT-S41	La Tour 1979	G amphibolite	46.07	1.09	13.18	12.19	0.18	11.55	10.66	0.91	1.65
H3-5	Hriskevich 1968	Nipissing gabbro	48.90	0.30	12.51	9.90	0.19	16.21	10.50	0.86	0.17
H3-6	Hriskevich 1968	Nipissing gabbro	50.63	0.51	17.73	6.71	0.17	6.24	11.28	1.97	1.55
IB3	La Tour 1979	Nipissing gabbro	52.46	0.70	14.79	12.17	0.19	7.18	10.43	2.34	0.73
PAR	La Tour 1979	Nipissing gabbro	51.93	0.62	14.74	9.95	0.18	7.52	11.20	1.78	0.70
MFY-1	McLennan et al. 1978	McKim composite	59.66	0.75	20.27	6.90	0.06	2.27	0.87	1.49	3.36
MFY-2	McLennan et al. 1978	Pecors composite	60.76	0.77	19.36	6.60	0.05	2.58	0.63	1.54	3.90

Abbreviations: bi = biotite; grt = garnet; ky = kyanite; CIA = Chemical Index of Alteration; G amphibolite = Grenville amphibolite; N amphibolite = Nipissing amphibolite; PIA = Plagioclase Index of Alteration; st = staurolite.

Appendix 2. Listing of chemical analyses from the literature relevant to this study — continued.

Sample No.	K_2O	P_2O_5	LOI	Total	Mg No.	CIA	PIA	Cr	Ni	Co	Sc	Rb	Ba	Sr	Nb
LN96-chill	0.73	0.07	1.81	100.88	59.6	52.4	10.4								
LN96-gabbro	0.87	0.07	1.44	101.17	58.4	55.5	10.9								
LT-H17	0.68	<0.01	2.62	100.56	70.4	51.6	11.3	244	109		44	22	97	102	
LT-H24	0.37	<0.01	1.94	99.15	71.5	49.5	13.0	487	115		37	12	42	131	1.9
LT-C208	0.44	<0.01	2.51	101.42	77.2	49.3	14.0	976	140		43	14	55	93	
LT-S51	0.75	<0.01	2.99	101.34	72.7	55.5	15.4	401	132		36	28	58	118	1.9
LT-S52	0.37	<0.01	2.66	100.38	71.4	55.4	18.4	382	105		31	11	47	142	1.9
LT-C209	1.20	<0.01	2.51	100.14	62.4	54.9	12.8	146	71		39	46	101	172	
LT-S59	0.37	<0.01	2.82	101.04	77.1	47.7	12.2	953	143		44	9	44	85	
LT-C210	0.77	0.01	2.78	99.90	77.1	48.3	10.4	937	140		44	25	49	95	1.9
LT-S63	0.68	<0.01	2.53	100.56	75.3	47.7	10.9	1012	159		49	19	160	84	3.0
LT-S94	0.30	<0.01	2.13	102.17	73.3	47.9	12.8	341	144		46	9	53	106	
LT-C211	0.85	0.02	1.84	101.23	54.8	56.2	12.7	24	37		44	19	101	142	
LT-S90	0.94	0.08	2.31	100.16	41.2	56.3	9.6	11	16		43	26	126	98	
LT-S70	0.94	0.27	1.54	100.71	20.7	56.7	7.4	3	4		40	19	131	82	4.0
LT-S122	0.40	<0.01	2.24	100.53	77.7	48.3	12.8	977	148		45	8	43	100	
LT-S168	0.15	<0.01	2.14	100.32	78.7	43.1	10.8	983	151		49	4	9	70	
LT-S72	2.10	0.50	1.56	100.61	34.0	51.4	3.7	22	20		44	54	533	96	7.0
LT-S102	1.21	0.41	1.92	102.32	34.9	53.9	8.9	87	57		44	23	325	91	6.0
LT-S109	0.97	0.28	1.71	100.75	44.0	50.4	9.0	92	32		45	11	174	77	1.9
LT-S112	1.78	0.41	1.26	100.55	37.1	48.3	5.1	81	45		46	56	343	67	12.0
LT-S117	1.10	0.14	1.40	100.90	40.4	52.0	8.5	54	32		49	15	192	69	4.0
LT-S126	0.22	0.94	1.64	101.56	38.4	50.9	15.1	39	28		32	5	39	113	4.0
LT-S138	1.32	0.36	1.43	100.84	43.9	49.0	7.8	164	45		45	17	252	112	2.0
LT-S141	1.09	0.34	2.00	101.21	48.3	52.1	9.2	140	78		38	19	291	80	4.0
LT-S146	0.99	0.14	1.52	100.90	38.4	57.4	10.3	10	43		26	19	232	283	6.0
LT-S151	0.87	0.33	1.50	101.11	44.0	51.2	9.7	153	50		45	20	218	91	3.0
LT-S157	0.82	0.13	1.99	100.55	46.7	56.8	12.7	93	82		34	16	274	123	4.0
LT-S159	2.14	0.61	2.49	102.71	37.5	50.0	2.7	52	15		50	30	346	34	10.0
LT-C205	1.01	0.36	2.37	100.16	43.4	54.2	9.8	160	73		34	23	408	109	7.0
LT-C206	0.97	0.37	1.61	100.58	32.4	53.7	8.9	72	38		35	22	359	84	4.0
LT-S145	1.38	0.44		98.94	35.6	48.3	6.2								
LT-S148	1.14	0.30		100.09	21.0	54.6	8.0								
LT-S149	3.47	0.22		99.63	49.3	52.1	-4.0								
LT-S163	0.83	0.09		98.96	36.3	57.8	10.7								
LT-S165	1.87	0.12		99.88	34.4	57.0	6.4								
LT-S41B	1.53	0.21		100.39	37.7	55.4	7.0								
LT-S41	1.65	0.12	2.63	100.23	65.2	49.9	6.0								
H3-5	0.17	0.03	1.72	101.29	76.4	52.0	11.8								
H3-6	1.55	0.05	2.05	98.89	64.8	54.5	12.5								
IB3	0.73	0.07	0.50	101.56	53.9	52.3	12.1							132	2.0
PAR	0.70	0.06		98.68	60.0	51.9	12.1	145	74						
MFY-1	3.36	0.08	4.46	100.17	39.4	78.0	2.8								
MFY-2	3.90	0.10	3.92	100.21	43.6	76.1	-2.8								

Appendix 2. Listing of chemical analyses from the literature relevant to this study — continued.

Sample No.	Zr	Y	Zr/Y	La	Ce	Pr	Nd	Sm	Eu	Gd	Dy	Er	Total REE
LN96-chill													
LN96-gabbro													
LT-H17	19	6	3.2										
LT-H24	26	8	3.3	4.21	7.25	0.89	4.52	1.49	0.58	1.90	2.65	1.84	25.3
LT-C208	10	3	3.3	2.30	4.86	0.62	2.89	0.94	0.56	1.37	1.65	1.33	16.5
LT-S51	15	5	3.0	3.38	7.20	0.70	3.55	1.16	0.63	1.51	1.91	1.48	21.5
LT-S52	16	3	5.3										
LT-C209	24	7	3.4	5.41	10.64	1.31	6.12	1.90	0.93	2.40	2.83	1.87	33.4
LT-S59	17	3	5.7	2.08	4.40	0.36	2.34	0.60	0.16	0.90	1.25	0.74	12.8
LT-C210	15	3	5.0										
LT-S63	17	5	3.4										
LT-S94	18	6	3.0										
LT-C211	36	10	3.6	12.18	21.72	2.28	9.93	2.60	1.09	3.15	3.34	2.20	58.5
LT-S90	73	20	3.7	16.25	33.69	3.44	16.29	4.14	1.58	5.03	5.75	3.59	89.8
LT-S70	82	24	3.4	19.73	43.69	4.71	22.50	5.65	2.11	6.17	6.25	4.20	115.0
LT-S122	11	3	3.7										
LT-S168	10	3	3.3	2.53	4.05	0.50	2.73	1.09	0.51	1.42	1.90	1.32	16.1
LT-S72	170	35	4.9										
LT-S102	140	28	5.0	39.05	82.20	8.25	41.04	9.71	3.10	10.13	10.01	6.04	209.5
LT-S109	75	19	3.9										
LT-S112	179	43	4.2										
LT-S117	79	23	3.4										
LT-S126	70	17	4.1	16.70	35.25	3.61	17.71	4.52	1.81	5.39	5.78	3.95	94.7
LT-S138	106	27	3.9	27.86	66.11	7.21	33.77	7.93	2.60	8.62	8.48	4.98	167.6
LT-S141	94	23	4.1	17.16	45.03	5.12	26.93	6.73	2.26	7.74	7.77	4.51	123.2
LT-S146	117	20	5.9	29.75	65.32	6.44	30.16	6.42	1.91	6.55	5.94	3.46	155.9
LT-S151	95	25	3.8										
LT-S157	132	28	4.7	25.35	56.45	5.71	26.25	6.37	1.90	6.94	7.72	4.91	141.6
LT-S159	195	42	4.6										
LT-C205	153	34	4.5										
LT-C206	134	27	5.0										
LT-S145													
LT-S148													
LT-S149													
LT-S163													
LT-S165													
LT-S41B													
LT-S41				14.71	33.36	3.55	18.08	3.88	1.59	3.92	3.62	2.29	
H3-5													
H3-6													
IB3	55	16	3.4	7.35	17.04	2.01	8.73	2.00	0.67	2.26	2.27	1.48	
PAR													
MFY-1				29.00	67.00		29.00	5.70	1.50	5.10	4.60	2.70	
MFY-2				36.00	82.00		34.00	6.40	1.60	5.50	4.50	2.70	

Appendix 2. Listing of chemical analyses from the literature relevant to this study — continued.

Sample No.	Source	Rock Type	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
CID-EM3	Card et al. 1977	Elsie Mtn st metapelite	57.38	1.00	25.33	1.13	4.86	0.05	2.48	0.34	2.08	2.01
CID-EM4	Card et al. 1977	Elsie Mtn st metapelite	59.40	1.17	23.10	1.10	4.19	0.04	1.58	0.59	1.30	4.59
CID-EM5	Card et al. 1977	Elsie Mtn metapelite	59.30	1.25	21.80	0.46	5.42	0.06	2.05	0.90	1.56	4.13
CID-EM6	Card et al. 1977	Elsie Mtn st-bi metapelite	61.48	0.88	21.77	2.64	4.10	0.06	2.74	1.39	1.32	2.20
CID-EM7	Card et al. 1977	Elsie Mtn. Metapelite	54.40	1.21	16.30	2.77	7.89	0.13	4.83	2.19	3.04	1.34
CID-MK1	Card et al. 1977	McKim metapelite	55.07	0.98	21.50	2.72	6.04	0.05	3.00	0.98	1.43	3.01
CID-MK2	Card et al. 1977	McKim metapelite	60.73	0.74	21.18	3.23	4.16	0.04	2.75	0.79	0.90	2.30
CID-MK3	Card et al. 1977	McKim metapelite	57.14	0.71	25.61	2.33	4.17	0.05	2.39	1.01	1.01	2.66
CID-MK4	Card et al. 1977	McKim sandstone	57.75	0.82	19.19	2.98	7.86	0.07	2.44	2.27	2.34	0.98
CID-MK5	Card et al. 1977	McKim ,etapelite	62.00	0.64	18.90	1.24	4.24	0.05	3.30	1.64	2.17	1.88
CID-MK6	Card et al. 1977	McKim metapelite	54.60	0.96	23.90	1.32	5.20	0.04	3.60	0.82	0.90	4.12
CID-MK7	Card et al. 1977	McKim metapelite	55.55	0.84	22.80	1.40	5.28	0.09	3.20	0.56	0.72	4.65
CID-MK8	Card et al. 1977	McKim metapelite	60.40	0.98	22.40	4.11	3.97	0.06	2.77	0.01	0.86	2.54
CID-MK9	Card et al. 1977	McKim greywacke	65.60	0.79	16.30	0.74	5.45	0.07	2.67	0.89	1.41	0.00
CID-P1	Card et al. 1977	Pecors siltstone	62.60	0.93	19.60	0.42	5.35	0.07	3.40	1.01	1.20	2.17
CID-ST10	Card et al. 1977	Stobie metapelite	58.40	1.52	12.40	2.92	8.39	0.15	3.10	6.53	1.85	1.04
CID-ST11	Card et al. 1977	Stobie metapelite	58.40	1.40	15.70	3.71	2.97	0.15	1.37	4.77	4.25	1.98
CID-ST12	Card et al. 1977	Stobie metapelite	56.60	1.27	19.80	3.17	5.42	0.06	2.50	1.18	2.07	3.69
CID-ST13	Card et al. 1977	Stobie metapelite	56.10	1.39	24.50	1.95	3.96	0.03	1.42	0.68	2.20	5.29
CW-MG28	Card et al. 1977	Murray granite	73.37	0.37	12.87	2.77		0.03	2.23	1.30	3.20	5.83
IN-1	Innes 1972	Granite plug	78.33	0.04	12.42	4.59		0.01	0.36	0.46	4.05	1.63
IN-2	Innes 1972	Creighton granite	75.90	0.33	12.40	0.52	1.73	0.04	0.24	0.97	3.06	5.30
IN-3	Innes 1972	Creighton granite	78.30	0.29	12.30	0.35	0.91	0.02	0.15	0.63	2.73	5.28
IN-4	Innes 1972	Creighton granite	70.34	0.42	13.99	1.76	2.34	0.04	0.77	2.07	3.56	4.53
IN-CCF10	Innes 1972	CCF argillite	57.40	1.19	23.80	1.60	3.89	0.03	1.58	0.38	1.43	5.43
IN-CCF11	Innes 1972	CCF argillite	64.00	0.82	20.00	0.29	4.32	0.05	1.58	1.15	2.19	3.21
IN-CCF12	Innes 1972	CCF rusty schist	83.00	0.30	8.35	0.04	1.95	0.02	0.78	0.27	0.87	1.74
IN-MK13	Innes 1972	McKim pelite	57.17	0.82	25.38	0.70	5.25	0.07	2.46	0.26	1.66	2.59
IN-MK14	Innes 1972	McKim schist	58.14	0.80	23.99	0.00	4.53	0.06	2.11	0.17	0.75	4.82
K120	Kwak 1967	Schist	53.53	2.15	26.80	1.78	3.98	0.06	2.80	0.81	0.88	5.17
K150	Kwak 1967	Schist	47.45	1.40	23.20	1.56	9.76	0.18	4.40	2.95	3.15	3.89
K156A	Kwak 1967	Schist	66.35	1.31	17.20	1.74	4.02	0.06	2.80	0.83	0.53	3.59
K156B	Kwak 1967	Schist	63.70	1.59	21.60	1.92	2.84	0.02	2.27	1.09	1.03	2.50
K231	Kwak 1967	Schist	57.50	1.38	22.84	1.33	5.52	0.09	3.44	1.10	1.00	3.31
K232B	Kwak 1967	Schist	63.95	1.22	18.81	1.06	4.64	0.05	2.67	1.36	1.07	3.18
K232C	Kwak 1967	Schist	60.95	1.23	19.90	1.88	3.24	0.05	2.60	1.49	2.27	3.74
K249	Kwak 1967	Schist	61.30	1.25	20.80	0.84	5.64	0.04	2.16	1.04	1.35	2.72
K290	Kwak 1967	Schist	69.65	1.51	16.25	2.20	3.72	0.07	1.96	0.94	0.65	2.13
K292	Kwak 1967	Schist	57.20	1.04	20.80	1.09	6.28	0.09	3.48	1.28	2.56	4.75
K293	Kwak 1967	Schist	53.60	1.46	21.50	1.32	10.60	0.11	2.99	1.94	2.29	2.77
K296	Kwak 1967	Schist	53.90	1.04	17.60	1.80	15.80	0.16	3.49	1.76	1.49	2.05
K78	Kwak 1967	Schist	58.80	1.23	23.36	1.70	6.24	0.08	2.89	0.76	0.83	3.12
K79	Kwak 1967	Schist	60.95	1.81	19.87	1.45	5.92	0.08	2.70	1.49	1.78	2.69

Abbreviations: bi = biotite; grt = garnet; ky = kyanite; CIA = Chemical Index of Alteration; G amphibolite = Grenville amphibolite; N amphibolite = Nipissing amphibolite; PIA = Plagioclase Index of Alteration; st = staurolite.

Appendix 2. Listing of chemical analyses from the literature relevant to this study — continued.

Sample No.	P_2O_5	H_2O^-	CO_2	LOI	Total	Mg No.	CIA	PIA	Cr	Ni	Co	V	Ba	Sr	Zr	Y
CID-EM3	0.11	0.07	0.64		96.77	42.9	87.0	53.8	250	80	10	150	600	200	80	10
CID-EM4	0.10	0.55	1.06		97.16	35.2	81.0	57.2	300	60	20	250	1200	150	150	10
CID-EM5	0.10	0.13	0.08		97.03	38.5	77.0	56.7	200	80	20	200	1000	100	150	20
CID-EM6	0.12	0.07	0.53		98.70	43.0	83.3	59.4	150	80	20	150	900	200	150	10
CID-EM7	0.14	0.03	0.05		94.24	45.3	71.4	49.2	200	80	20	250	400		150	10
CID-MK1	0.11	0.02	0.12		94.89	38.6	80.2	52.6								
CID-MK2	0.09	0.00	0.20		96.91	41.0	84.8	59.3								
CID-MK3	0.09	0.00	0.12		97.17	40.5	84.9	55.4								
CID-MK4	0.11	0.02	0.02		96.81	29.2	77.5	53.9								
CID-MK5	0.11	0.05	0.00		96.17	52.3	76.9	58.6								
CID-MK6	0.18	0.04	0.00		95.64	50.1	80.4	53.1								
CID-MK7	0.15	0.07	0.00		95.24	46.6	79.4	54.3								
CID-MK8	0.08	0.12	0.18		98.18	39.2	87.4	59.0	200	80	10	200	500	100	150	30
CID-MK9	0.12	0.26	0.04		94.04	43.8	87.8	63.5								
CID-P1	0.08	0.12	0.12		96.83	51.4	82.1	60.8	250	70	20	100	500	300	120	
CID-ST10	0.17	0.12	0.10		96.47	33.4	57.1	55.6	10	15	30	30	400	250		
CID-ST11	0.05	0.30	0.15		94.75	27.9	59.1	51.3	100	30	20	10	300	50		
CID-ST12	0.12	0.23			95.88	35.0	74.0	53.0	150	15	30	15	1200	200		
CID-ST13	0.10	0.10	0.10		97.62	30.7	75.2	52.2	150	10	30	30	800		70	
CW-MG28	0.02				101.99	61.5	55.5	69.0		10						
IN-1					101.89	13.4	66.9	72.9								
IN-2	0.04				100.53	16.3	57.1	71.8								
IN-3	0.02				100.98	17.9	58.7	74.7								
IN-4	0.09				99.91	25.9	57.9	65.2								
IN-CCF10	0.01	0.11	0.01		96.74	34.6	76.7	54.9	30	30	10	50	600	100	150	80
IN-CCF11	0.87	0.03	0.21		98.48	38.1	75.9	60.6	100	70	20	150	1500	100	150	80
IN-CCF12	0.04	0.14	0.14	0.51	97.87	41.2	75.3	82.0	30	30	10	130	600	30	120	15
IN-MK13	0.29	0.08	0.74	3.52	100.17	42.7	87.1	54.3	200	60	20	150	600	200	100	10
IN-MK14	0.30	0.09	1.11	3.07	98.74	45.4	83.8	56.9	200	60	15	150	800	100	80	7
K120	0.16	0.22			98.12	47.2	79.6	52.0								
K150	0.44	0.10	0.11		98.38	41.3	70.1	41.3								
K156A	0.09	0.15			98.52	47.2	77.7	65.6								
K156B	0.07	0.21			98.63	47.0	82.4	62.1								
K231	0.16	0.20			97.67	47.7	80.8	55.9								
K232B	0.02	0.21			98.03	46.0	77.0	62.3								
K232C	0.10	0.24			97.45	48.4	72.6	57.3								
K249	0.11	0.30			97.25	37.6	80.3	59.2								
K290	0.04	0.19			99.12	38.0	81.4	68.7								
K292	0.10	0.08			98.67	46.1	70.8	52.9								
K293	0.10	0.07	0.02		98.68	31.1	75.5	49.5								
K296	0.11	0.08			99.20	26.3	76.9	51.3								
K78	0.14	0.06			99.15	39.9	83.2	57.5								
K79	0.17	0.09			98.91	40.0	76.9	58.1								

Appendix 2. Listing of chemical analyses from the literature relevant to this study — continued.

Sample No.	Source	Rock Type	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O
PW1a	Pearson 1959	Granite gneiss	70.25	0.41	11.91	3.08	3.51	0.08	0.46	1.74	3.12	4.84
PW1e	Pearson 1959	grt gneiss	56.85	0.45	18.92	1.13	6.28	0.09	2.99	5.67	2.88	2.79
PW212	Pearson 1959	grt-bi gneiss	50.45	1.65	18.30	1.57	8.40	0.11	4.79	6.00	2.28	3.31
PW216	Pearson 1959	Gneiss	76.25	0.46	10.90	0.62	2.32	0.03	0.92	1.25	2.47	2.75
PW217	Pearson 1959	grt gneiss	82.55	0.24	8.20	0.71	1.21	0.03	0.31	0.89	1.66	2.72
PW218	Pearson 1959	grt gneiss	61.96	0.62	16.10	0.87	5.80	0.14	1.93	1.59	3.00	5.75
PW219	Pearson 1959	ky gneiss	60.90	1.56	23.00	1.09	4.84	0.03	1.66	0.30	0.48	4.84
PW220	Pearson 1959	ky gneiss	64.82	1.45	12.60	1.20	10.20	0.18	2.06	4.01	0.47	1.35
PW221	Pearson 1959	Quartzite	90.39	0.27	3.10	0.51	1.40	0.02	0.30	0.30	1.57	0.53
PW222	Pearson 1959	Gneiss	70.14	0.36	14.00	0.64	3.12	0.09	3.40	0.30	2.32	4.17
PW223	Pearson 1959	grt gneiss	71.12	0.45	13.01	0.69	4.00	0.17	1.27	1.36	2.35	3.50
PWII	Pearson 1959	Granite gneiss	72.86	0.29	11.90	1.92	0.82	0.04	0.40	1.39	3.30	5.05
PWVa	Pearson 1959	ky gneiss	54.64	0.78	25.36	0.98	7.16	0.07	2.54	1.57	1.11	3.81
PWVb	Pearson 1959	ky gneiss	56.67	0.55	25.16	0.42	6.53	0.07	2.94	0.78	1.95	3.28

Sample No.	P_2O5	H_2O^-	CO_2	Total	Mg No.	CIA	PIA
PW1a	0.20	0.04	0.34	99.98	11.5	56.0	-29.9
PW1e	0.49	0.04	0.61	99.19	42.2	63.8	7.3
PW212	0.00	0.27	0.07	97.20	46.5	61.4	4.0
PW216	0.00	0.08	0.01	98.06	36.3	62.8	-12.3
PW217	0.00	0.08	0.33	98.93	23.0	62.4	-27.1
PW218	0.00	0.12	0.09	97.97	34.3	61.1	-22.6
PW219	0.00	0.06	0.14	98.90	33.7	80.8	-2.7
PW220	0.00	0.10	0.12	98.56	24.6	68.8	4.0
PW221	0.00	0.06	0.11	98.56	22.3	57.5	-9.1
PW222	0.00	0.13	0.11	98.78	62.1	67.7	-19.8
PW223	0.00	0.12	0.08	98.12	32.9	64.6	-13.6
PWII	0.00	0.04	0.57	98.58	21.9	56.5	-34.1
PWVa	0.04	0.13	0.80	98.99	36.0	81.7	9.1
PWVb	0.05	0.09	0.61	99.10	43.1	82.3	11.5

Abbreviations: bi = biotite; grt = garnet; ky = kyanite; CIA = Chemical Index of Alteration; G amphibolite = Grenville amphibolite; N amphibolite = Nipissing amphibolite; PIA = Plagioclase Index of Alteration; st = staurolite.

Metric Conversion Table

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 023	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.307 951	cubic yards	1 cubic yard	0.764 554 86	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 962	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 747	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 622 6	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311 3	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 90**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

	Multiplied by	
1 ounce (troy) per ton (short)	31.103 477	grams per ton (short)
1 gram per ton (short)	0.032 151	ounces (troy) per ton (short)
1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

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